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AGRICULTURAL RESEARCH CORPORATION

WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT



VOLUME I

SUMMARY OF KADUGLI

SEDENTARY AND TRANSHUMANT PRODUCTION SYSTEM

RESEARCH PROGRAM RESULTS

KADUGLI RESEARCH STATION

WSARP PUBLICATION No. 41

SEPTEMBER 1985

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AGRICULTURAL RESEARCH CORPORATION
WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

THE GOVERNMENT OF SUDAN
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
THE WORLD BANK
CONSORTIUM FOR INTERNATIONAL DEVELOPMENT
WASHINGTON STATE UNIVERSITY

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THE WESTERN SUDAN AGRICULTURAL RESEARCH PROJECT

IS SUPPORTED BY

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US AGENCY FOR INTERNATIONAL DEVELOPMENT

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PREFACE

by

Mukhtar Kenani

The Agricultural Research Corporation has a long and successful history of commodity oriented research. In an effort to complement this well-established research program, the Western Sudan Agricultural Research Project has undertaken to implement a farming systems research program for rainfed agriculture in the Kordofan and Darfur Regions of Western Sudan. The Kadugli Research Station is one of two research stations in the Kordofan Region being supported by this project, and the only station located in South Kordofan.

One of the several merits of farming systems research is the encouragement of interdisciplinarity and the fostering of a teamwork spirit among scientists. Our station scientists have found that such a spirit had enabled them to address the production constraints of traditional agriculture in a more holistic fashion than would normally have been the case in a more traditional research program. With the experience of this year's research activities scientists have a better understanding of the biological and the socioeconomic linkages that characterize traditional systems of agriculture in the Nuba Mountain region.

Research activities during the season have offered a good opportunity to further assess the ways and means traditional producers exploit their resource base and a clearer picture of the overall agricultural potential of the station's target area. In addition, the station has strengthened its training program for all research disciplines. Thus, technicians, apprentices, and field assistants have developed their abilities to better understand and appreciate, and to supervise, on-farm and on-station research trials.

What follows in this volume is a summary of our research program results for 1984/85. The details of individual trials, methodologies, results, and discussions are contained in subsequent volumes, i.e. Volume 2 Sedentary Production System Research Program Results, 1984/85, and Volume 3 Transhumant Production System Research Program Results 1984/85. The intent of this volume is to provide an overview of where our 1984/85 research program has taken us and where we hope to go from here.

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SUMMARY OF KADUGLI SEDENTARY AND TRANSHUMANT PRODUCTION SYSTEMS
RESEARCH PROGRAM RESULTS, 1984/85

EXECUTIVE SUMMARY

THE KADUGLI STATION RESEARCH PROGRAM

The Kadugli Station has focused its research program on the two predominate production systems in South Kordofan. The first of these is the traditional sedentary system of the Nuba Mountain area, and here, research efforts have been directed at exploiting the potential for development of an integrated, mixed-farming production system. An interdisciplinary research program, utilizing both on-station and on-farm trials, has focused on: (1) testing new and improved varieties and identifying improved cultural practices for sorghum, sesame, and cowpeas, the principal crops grown in the area; (2) examining new and improved dual-purpose legumes for incorporation into the existing cropping system; (3) using conserved forages, crop residues, and modified animal husbandry practices to improve livestock productivity; (4) initiating on-farm trials, in cooperation with the Nuba Mountain Rural Development Project, with draft animals to exploit the potential for incorporating animal traction into the existing cropping system; and (5) providing socioeconomic data on traditional households and commodity price information for establishing guidelines for research program development and evaluating the efficiency of local markets and farmer marketing strategies.

The second major production system of the area is the Baggara, transhumant livestock production system. The research program addressing production constraints in this system has focused on: (1) evaluating rangeland productivity and identifying potentially adoptable improvements in natural resource management practices; (2) evaluating the productivity and seasonal nutritional status of livestock under traditional management practices and initiating in-herd/flock supplemental feeding trials; and (3) providing socioeconomic data to evaluate producer-market interactions, marketing strategies, and elasticities for the output of cattle, sheep, goats, and livestock products.

RESEARCH RESULTS, RECOMMENDATIONS, AND RESOURCE REQUIREMENTS

The details of previous research activities and results have been documented elsewhere (refer to list of WSARP publications, page 94). What follows is a general summary of results achieved to date, recommendations for future research activities, and a broad indication of the anticipated future resource requirements.

Traditional Sedentary Production System Research Results

1. Cultural practice trials have concentrated on using improved, short-maturing varieties of sorghum, specifically examining weeding practices, plant populations, seed dressings, fertilizer responses, and improved soil and water conservation practices. Results to date indicate that sorghum yields can be maximized by using improved, short-maturing varieties (eg. Dabar, Gadam El Hamam); weeding 2 and 4 weeks after plant emergence; using 20 cm between plants within rows and 60 cm between rows; and using phosphate fertilizer at the range of 40 kg/ha. Mulching was shown to increase yields 2.3 times over traditional practices; however, analysis showed that mulching must be adapted to farmer conditions to be economically feasible.

2. Variety screening trials have been substantially reduced in number during the past several years, with the present focus of screening trials concentrating on the most important crops grown in the area (sorghum, sesame, and cowpeas), as well as several crops considered highly promising for introduction (eg. mungbeans). Selection for advancement to the next cropping season to on-farm trials was based not only on yield, but also on: Striga-resistance (sorghum); low pod shattering (sesame); and bean and forage yields and degree of nodulation (cowpeas and mungbeans). Several varieties of cowpeas and mungbeans have been included in on-farm trials for 1985.

3. On-farm trials have shown that: (1) Hageen Dura 1 hybrid sorghum performed well under farmer-managed conditions and farmers are willing to increase their acreage provided seeds are available in a timely manner; (2) improved, short-maturing varieties of sorghum, with seed dressing and fertilizer out-yielded all the local varieties with traditional practices across all locations (1985). Researcher-managed fertilizer trials with improved, short-maturing varieties of sorghum showed that the rates of

return to improved varieties with the long-term average yields for South Kordofan ranged from 268% to 404%.

4. Legume trials have concentrated on those showing a high potential for grain production for household consumption and/or sale, as well as for forage production. In this regard, cowpeas, mungbeans, guar, and pigeon peas show high potential. On-farm trials with cowpeas (1985) indicated that early planting (June 15-30), plant spacing of 20 cm within rows and 50 cm between rows, could be expected to yield 2-3 tons of forage/ha with an effective rainfall of 350-500 mm. Preliminary economic analysis showed that the highest benefit/cost ratios were found with legumes being intercropped with sorghum and sesame.

5. On-farm livestock trials have concentrated on the introduction of draft and improvement of nutrition using bovine animals. Economic analysis of animal draft trials demonstrated benefit/cost ratios ranging from 1.15 to 3.45 over a five-year period, when only rental benefits were considered, and 4.92 to 11.24 over a similar period with the addition of welfare benefits. Supplemental feeding trials have shown that quite high levels of good quality forage are required to make a significant impact on production and such forage is scarce and expensive in the areas. The conservation of native grass as hay is presently not feasible because of a poor quality product resulting from problems in harvesting, curing, and storage.

Future Research Activities for the Sedentary Production System

1. Expand researcher/farmer-managed trials to examine the adoptability of: (1) introduction of improved varieties of sorghum (Gadam El Hamam, Hageen Dura 1) and (2) improved cultural practices (weeding, plant populations, phosphate fertilizer and seed dressing) in relation to labor availability and to alternatives for resource allocation.

2. Initiate researcher-managed, on-farm trials to evaluate the introduction of improved varieties of sorghum, sesame, and cowpeas on jubrakas (housegardens) to increase the availability of food for household consumption during the "hungry period."

3. Conduct selected on-station variety screening trials, focusing on sorghum, sesame, cowpeas, mungbeans, guar, pigeon peas, maize and groundnuts.

4. On-station development and analysis of on-farm feasibility of improved soil/water management practices for both far field and jubra production activities.

5. Expand on-farm draft trials and include pilot study designed to assess the potential for the development of village-level credit programs supported by revenue generated from ox-cart rentals.

6. Conduct in-herd/on-farm diagnostic studies to critically evaluate the seasonal nutritional status of sedentary livestock and initiate strategic supplemental feeding trials which focus on improving the utilization of low quality crop residues and natural forages through the provision of high quality forage legumes and supplemental phosphorus. Both large and small ruminant species will be utilized in these trials.

Baggara, Transhumant Livestock Production System

1. Rangeland productivity and utilization studies in the Nuba Mountains have shown that: (1) most rangelands are in only fair condition due to a dominance in the herb layer of tall, coarse, fast-maturing annuals of low nutritional quality, largely the result of inadequate grazing pressures during the growing season and the high incidence of burning during the early-dry season; (2) wood vegetation on most rangelands is declining in abundance and in diversity in response to existing pressures from selective browsing, frequent burning, and a rising demand for land and wood products; (3) fires annually consume an estimated 25-30% of the net primary production and prevention of these fires would be sufficient to support a 43% increase in livestock biomass; the latter would have no adverse impact on range during the dry season; and (4) approximately 30% of rangelands are unutilized by livestock during the dry season because of absence of water.

2. Inefficient utilization of the natural resource base is a fundamental problem for all livestock producers in South Kordofan, and is primarily the result of: (1) inability and /or unwillingness to cope with physical (mud) and disease factors associated with rainy season use of cracking clay plains; (2) widespread burning and limited sources of water during the dry season; (3) land-use conflicts among producer groups over land and water resources; and (4) absence of effective land-use policies to

allow interventions for improved grazing management and rangeland improvement.

3. Monitoring studies with sentinel herds have shown that cattle can be maintained year-round on southern rangelands at levels of productivity equal to or greater than that found under migratory practices, providing that: (1) animals are given at least one year to adapt to climatic conditions; (2) year-round sources of natural forage and water are available; and (3) the strategic control of ectoparasites is practiced.

4. In-herd studies of the seasonal nutrition status of transhumant cattle and sheep have shown that: (1) for cattle, phosphorus content of the graze ration ranges on a seasonal basis from 0.05-0.13%; adult animals are in a negative energy/nitrogen balance and 95% of lactating animals are clinically deficient in phosphorus during the dry season; adult animals are in a positive energy/nitrogen balance while the majority of lactating animals are clinically deficient in phosphorus during the rainy season; and (2) for sheep, energy and phosphorus appear to be the most limiting nutrients for pregnant ewes during the rainy season; energy, crude protein, and phosphorus were limiting for lactating ewes during the mid-dry season; and energy was apparently the most limiting nutrient for adult ewes during the late dry season.

5. Researcher-managed, in-herd, dry season supplemental (sesame cake at maintenance levels) feeding trial with adult, female, transhumant cattle (1984/1985) showed that: (1) supplemented cattle gained significantly more weight, produced significantly more milk, had calves with significantly higher birth weights, and maintained significantly higher plasma phosphorus levels, than did unsupplemented cows; (2) during the subsequent rainy season, previously unsupplemented cows gained more weight than previously supplemented cows, and there was no difference in milk production between groups; (3) lactating cows showed the lowest phosphorus levels in the rainy season; and (4) the marginal benefit/cost ratio for the dry season supplementation of lactating cows was -0.18%, due to the relatively high purchase and transport costs of sesame cake.

6. Researcher-managed, in-flock, dry season supplemental (sesame cake at 1/2 maintenance levels plus a phosphorus supplement) feeding trial for breeding ewes (1985) showed that the level of supplementation was not sufficient to demonstrate any significant improvement in productivity

between treatment groups. This was primarily the result of very poor grazing in the study areas as a result of the 1984 drought. 16% of all lambs less than 3 months old died of respiratory infections; ewe losses ranged from 12-20%, being highest in unsupplemented, control animals.

7. Livestock marketing studies indicated that producer strategy was quite complex, depending on rainfall patterns, commodity prices, demand for liquidity, and scale on anticipated purchases. The rapid increase in the market price of sorghum, resulting in a price ratio of male cattle/sack-sorghum of 1:1 by May, 1985, made the usual practice of selling small ruminants for most staple food purchases impossible to follow during the 1985 dry season.

Future Research Activities for the Baggara, Transhumant System

1. Proposed feasibility study, in collaboration with the regional government, for introducing water on a limited basis to increase the availability of dry season grazing, accompanied with an improved system of grazing management and strategic measures for animal disease control.

2. Studies on the marketing of livestock by transhumant producers and milk production, consumption and sales, contribution to transhumant household income.

3. Analysis of forage plants selected by grazing ruminants in relation to their seasonal nutritional status.

4. Implementation of improved management and husbandry practices for the research station's sentinel herd to assess potential productivity of traditional cattle maintained continuously on southern ranges.

5. Phosphorus supplementation of transhumant cattle during the rainy season.

6. Phosphorus supplementation of pregnant ewes during the rainy season and supplemental feeding of early-weaned lambs during the dry season.

Resources Required for Future Activities

1. Provision of inputs for research trials on a timely basis, eg., seed, seed dressings, fertilizers, livestock supplements (phosphorus), etc.

2. Logistical support for field activities, eg., vehicles, technical staff, etc. (including formal agreements for sharing resources with

extension, veterinary/livestock production, Nuba Mountain Rural development Project, Nuba Mountain Agricultural Production Corporation personnel).

3. Adequate scientific research staff: crop and forage agronomists (2); economists (2); range livestock specialists (2); sociologist (1); and agricultural engineer (1).

4. Establishment of an information network to facilitate the collaboration/sharing of research results among organizations involved in rainfed agricultural production in the Sudan and outside the country.

5. Long-term commitment of funding to allow for the continuity and development of research programs.

6. Establishment of a research station training and information service oriented towards producers, local merchants, and the local private sector at large, and aimed at disseminating information on proven technologies developed at the station or at other stations under similar production conditions.

SUMMARY OF THE SEDENTARY PRODUCTION SYSTEMS

RESEARCH PROGRAM RESULTS - 1984/1985

A. INTRODUCTION¹

In the sedentary production system of the Nuba Mountains the majority of households raise sorghum (dura) as the primary and staple food crop. In the region, preliminary surveys indicated that sorghum comprised approximately 56% of the cropped area, sesame and cotton 19%, cowpeas 16%, groundnuts 4% and millet 1%. Intercropping occurs on approximately 34% to 45% of the area, generally with sorghum intercropped with either sesame or cowpeas. The majority of households have housegardens, jubrakas, which are usually planted to food crops, principally early-maturing varieties of sorghum, maize, cowpeas, and a variety of vegetables. Harvests from these housegardens provide an important food source during the "hungry period" which extends from July until the harvest of the first far field crops (so called because of the distance from the household) in October.

Field crops are usually grown under a bush-fallow system of cultivation where a piece of land is continuously cropped until soil fertility becomes depleted, or in the case of sorghum, until infestation with the parasitic weed Striga becomes so severe that further cropping is no longer feasible. The land is then left for a number of years until soil fertility is restored and/or Striga infestation is reduced. Systematic crop rotation systems are essentially nonexistent in the region.

Planting and weeding are traditionally done using a silukab (pointed stick) and a jeraia (push hoe), respectively. For sorghum no special attempt is made to plant in rows, as is the case for cotton and groundnuts, with hills being planted every 1.6 by 1.4 m.² Sorghum and sesame are usually weeded twice, but often the first weeding comes too late when early growth has already been depressed by weed competition. The sorghum harvest usually begins 90 to 130 days after emergence, depending on the variety,

¹A more complete description of the Sedentary Production System in the Nuba Mountains can be found in WSARP publication #22, "Research Program for the Kordofan Region, 1984/85."

²Woldetatos, 1984, personal observation.

beginning on the housegardens in October and ending on the far fields in February. Sesame is usually harvested beginning in mid-October, cotton from December through February, and groundnuts from September through October. Harvesting and threshing are traditionally done by hand.

Livestock are of secondary importance in this farming system because the livelihood of sedentary farmers is centered on the cultivation of crops. For cattle and small ruminants, the seasonal pattern of grazing involves the jebel (hill) and footslope vegetation during the rainy and early dry seasons, followed by the use of cracking clay plains after the main field crops have been harvested. A significant number of sedentary farmers send their cattle north during the rainy season in a manner comparable to that used by transhumant producers. Although virtually every sedentary household owns some livestock, the distribution is highly variable. Approximately 70% of households own goats, 50% own cattle, and 11% own sheep.

The existing constraints on production for the traditional sedentary farmer in the Nuba Mountains limit marketable surpluses which could generate more cash sales, and keep most farmers in a state of relative poverty. Insufficient resources, e.g. limited availability of labor during peak work periods, inefficient tools for cultural practices, poor access to credit, few technological inputs such as improved seeds and fertilizer, and poorly developed roads and markets impose limited production alternatives and incentives on sedentary households. Some of the factors that inhibit producers from taking risks to produce more crops include unstable markets, unreliable transportation, and insecure land tenure.

The objectives of the sedentary production system research program are to: (1) stabilize and improve the intensity of agricultural production by introducing better methods of cultivation and improved varieties, and by introducing new and improved food and forage legumes into better intercropping and crop rotation systems; (2) improve the efficiency of labor by introducing animal draft as a means to reduce labor bottlenecks, allow expansion of the land under cultivation, and provide a means to market surplus food and/or cash crops outside the village domain; (3) improve the integration of cropping and livestock production activities by examining the potential for the conservation of crop residues and legume forages and for the more efficient use of these as supplemental animal

feeds; and (4) provide traditional producers with the means to ultimately improve their welfare and income through the encouragement of local farmer cooperatives.

The strategy to accomplish these objectives involves the design and testing of improved technologies which will increase the efficiency and utilization of land, labor, and capital, while improving the managerial capacity to sustain long-term increases in agricultural productivity. The results of our research activities for 1984/85, to design and evaluate such technologies for traditional sedentary farmers in the Nuba Mountain region of South Kordofan, follow.

Crop Production Environment:

On-station agronomy research trials for 1984 were conducted on a cracking clay (vertisol) at the station research farm. Additionally, the groundnut and pearl millet trials were put on coarse textured, footslope soils (alfisol) in the research station compound. The sites for the on-farm trials were Kululu, Bilenya, Shaer and Elafein. All four of these sites had cracking clay soils (vertisols).

Land preparation at the research station farm included disc-plowing, scraping, and leveling using a heavy chain attached to a tractor. The plowing operation was poor and, thus, the farm had numerous undulations. It took many trips of back and forth driving to level off the plots which eventually led to heavy clay pan formation. No mechanized land preparation was used in the on-farm trials at Kululu, Bilenya, and Shaer.

The rainfall during the 1984 crop season was low and poorly distributed (refer to Table 1 and Figure 1). However, it provided an opportunity for screening varieties for drought tolerance. Bilenya had the lowest rainfall, 268.5 mm, while Kululu had the highest, 363.5 mm.

TABLE 1

1984 RAINFALL DATA AT THE AGRONOMY TRIAL SITES (KADUGLI)

Dates	Seraaf Farm	ARC/WSARP Compound	Bilenya	Kululu	Shaer
----- mm -----					
May: 1- 7	4.2	4.2			
8-14	0.0	0.0			
15-22	38.1	38.1			
23-31	12.7	12.7			
Total	55.0	55.0			
June: 1- 7	42.0	42.0			
8-14	16.5	16.0			
15-22	15.0	15.0			
23-30	28.0	28.0		40.0	
Total	101.5	101.0		40.0	
July: 1- 7	71.0	35.8	48.0	21.5	64.2
8-14	10.2	4.8	16.5	71.5	6.0
15-22	42.0	21.2	3.0	20.0	19.0
23-31	24.5	24.9	26.0	20.0	33.5
Total	147.7	86.7	93.5	133.0	122.7
Aug: 1- 7	35.0	91.2	27.0	31.0	62.0
8-14	14.5	6.0	0.0	8.0	0.0
15-22	28.5	41.0	29.0	29.0	24.0
23-31	0.0	5.0	43.0	17.0	0.0
Total	78.0	143.2	99.0	85.0	86.0
Sept: 1- 7	5.0	3.3	0.0	3.0	35.0
8-14	35.7	41.3	30.0	64.0	22.5
15-22	13.5	19.2	16.0	0.0	27.1
23-30	0.0	0.0	10.0	5.0	0.0
Total	54.2	63.8	56.0	72.0	84.6
Oct: 1- 7	2.0	4.5	14.0	21.0	7.0
8-14	1.0	3.5	0.0	12.5	13.0
15-22	12.0	20.8	6.0	0.0	0.0
23-31	0.0	0.0	0.0	0.0	0.0
Total	15.0	28.8	20.0	33.5	20.0

TABLE 1 (CONT.)

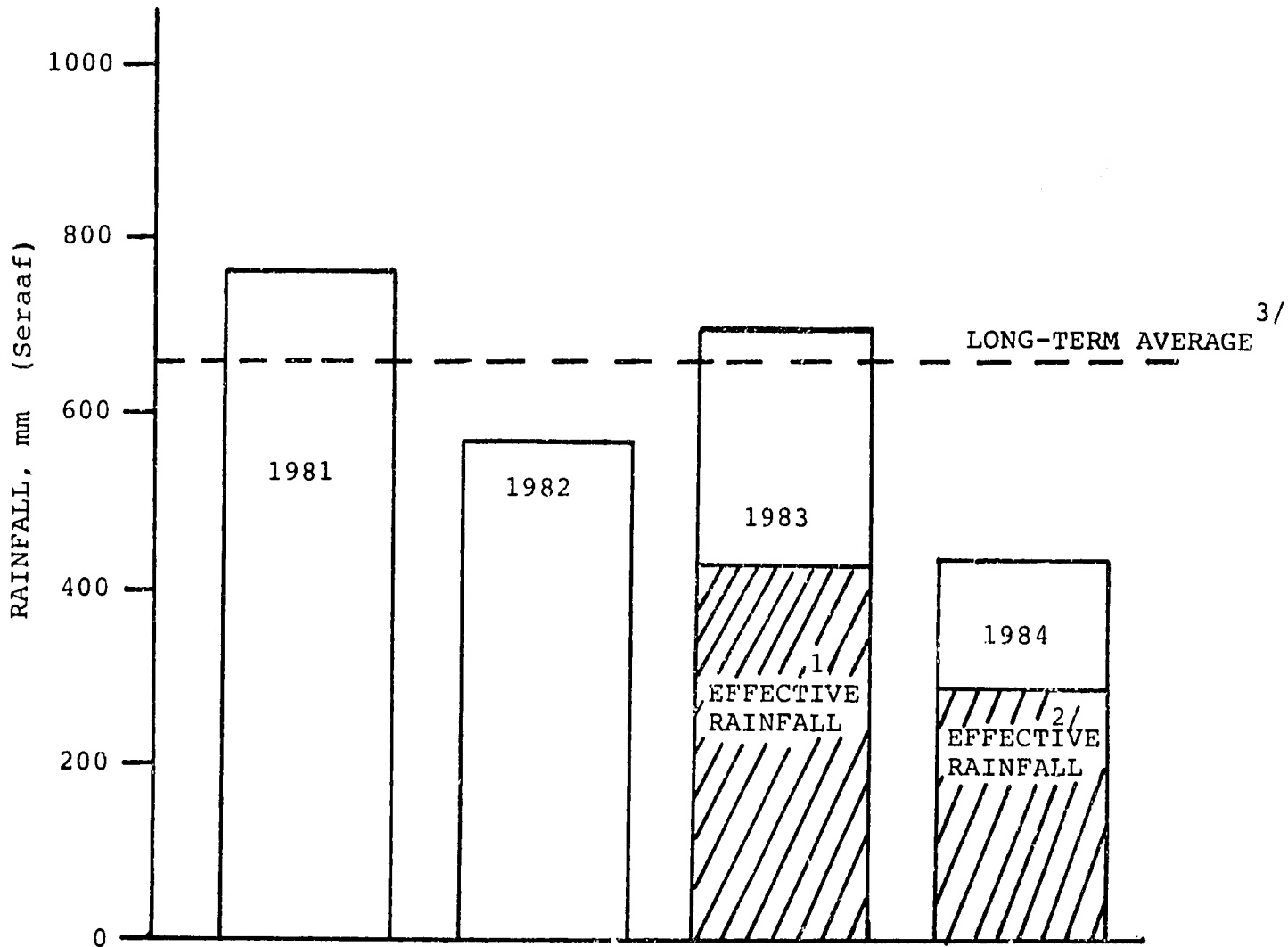
1984 RAINFALL DATA AT THE AGRONOMY TRIAL SITES (KADUGLI)

Site	Total Rainfall mm (May-Oct.)	Effective Rainfall, mm ^{1/}
Seraaf Farm	451.4	294.9
ARC/WSARP Compound	478.5	322.5
Bilenya	268.5	268.5
Kululu	363.5	363.5
Shaer	313.3	313.3

1/ Effective rainfall is the amount which fell
after planting (July - October)

FIGURE 1

COMPARISON OF RAINFALL (mm for June through October) FOR
1981 - 1984 WITH THE LONG-TERM AVERAGE FOR THE SAME PERIOD



- 1/ Total rainfall (mm) which fell after the planting of the 1983 agronomy trials on the Seraaf Compound.
- 2/ Total rainfall (mm) which fell after the planting of the 1984 agronomy trials on the Seraaf Compound.
- 3/ Long-term average rainfall (1941-1978) for the period June through October. Hunting Technical Services. 1980. South Kordofan Central Districts Indicative Development Plan.

B. AGRONOMY RESEARCH PROGRAM RESULTS - 1984/1985

Contributing Scientists: Dr. T. Woldetatos, Agronomist; Dr. T. Gillard-Byers, Agricultural Economist, Dr. L. Arya, Soil and Water Specialist

1. INTRODUCTION

One of the principal objectives of the sedentary production system research program for 1984/85 was to stabilize and improve agricultural production for traditional producers by developing better methods of cultivation and improved varieties of food and cash crops which are traditionally grown in the Nuba Mountain area. Accordingly, the agronomy program focused its activities in three primary areas: (1) improved cultivation practices; (2) variety screening trials; and (3) farmer- and researcher-managed on-farm trials. The research activities were thus designed and implemented on-station (researcher-managed) and on-farm (researcher-managed and/or farmer-managed).

The on-station trials included variety screening and development on sorghum, sesame, cowpeas, mungbeans, soybeans, sunflower, pearl millet, and groundnuts; and cultural practice trials mainly on sorghum. The on-farm/farmer-managed trials were on: (a) the effect of phosphorous and seed dressing (Aldrex T) on sorghum; and (b) Hageen Dura/demonstration, whereas the researcher-managed trials were on: (a) the effect of nitrogen and phosphorous on sorghum; (b) sorghum sesame intercropping with legumes; (c) the effect of seed dressing and timely practices on sorghum; and (d) Striga resistance trials.

2. ON-STATION TRIALS

a. Cultural Practice Trials

Some of the constraints of crop production in the Nuba Mountain area are low soil fertility (Gingrich, et al., 1984), poor soil management, poor weeding practices, and plant population which are mostly spaced wide apart and sometimes thickly populated due to lack of thinning. Therefore, cultural practice trials were designed and implemented on: (1) time and

frequency of weeding; (2) plant spacing; (3) fertilizers; and (4) soil and water management and conservation.

The objective of these trials is to develop the best agronomic practices that would optimize field crop production under the prevailing environmental conditions at the Nuba Mountain region.

♦ Time and Frequency of Weeding:

The losses caused by weeds are manifold. Among these are: (1) yield reduction due to competition for moisture, light, mineral nutrients, and carbon dioxide; (2) decrease in crop quality; (3) cost of weed control; (4) losses due to plant diseases and insects that are harbored and protected by weeds; (5) injury to livestock; and (6) decrease in land value. In general, the traditional Nuba Mountain farmers delay their weeding operations up to 4-5 weeks after sorghum emergence. Such poor weeding practices promote early weed establishment that would out-compete the main crop when it is at its weakest growth stage and, thus, eventually give poor yield. Therefore, an experiment was conducted on the effect of time and frequency of weeding on sorghum, using Gadam El Hamam. The experimental design used and materials and methods are discussed in Volume 2, Kadugli Annual Research Report (Woldetatis, 1985).

Due to the low rainfall, the sorghum plants could not yield harvestable heads. Nevertheless, we obtained significantly lower sorghum stover yields when the weeding was delayed up to 4 weeks after sorghum emergence. Weeding at 2-4 weeks after sorghum emergence was among the best weeding practices. Therefore, in order to reduce weed competition and increase sorghum yield we recommend that: (1) weeding should not be delayed for more than 2-3 weeks after sorghum emergence; and (2) the benefit/cost ratios be computed in order to determine the economic threshold level of weeding frequency.

The following weeding treatments are suggested for the 1985-1986 growing season (WASE = weeks after sorghum emergence):

- (1) 2 WASE
- (2) 2 WASE + 4 WASE
- (3) 3 WASE
- (4) 3 WASE + 5 WASE
- (5) atrazine with 1 1/2 kg/ha applied as postemergence at 2 WASE
- (6) weed-free plot

◆ Plant Spacing Trials:

Plant population is determined by soil fertility, soil moisture, plant architecture, and solar radiation. The recent decline in rainfall and poor soil fertility in the Nuba Mountain area calls for an immediate plant spacing trial.

The traditional farmers broadcast sorghum in hills spaced at 1.4 by 1.6 m with 3 plants per hill which give approximately 13,390 plants/ha. This clearly indicates how sparsely the sorghum plants are distributed in the field. On the other hand the standing station-recommended plant population of 150,000 plants/ha was too dense for the prevailing low rainfall and poor soil fertility level. Therefore, research on sorghum plant spacing trials was conducted in order to determine the optimum plant population. The spacing between plants within the row were 10, 20, 30 and 40 cm. For experimental details refer to Woldetatis (1985).

The 20 cm spacing between plants gave higher stover weight of sorghum than did the 10, 30 and 40 cm spacing, respectively. Additional plant spacing trials are recommended for the 1985-86 crop season. The suggested spacing between rows and within row per crop are shown below.

Crop	Spacing (cm.)	
	between rows	within rows
Sorghum	60, 90, 120	20, 30, 40
Cowpeas	40, 60, 80	20, 30, 40
Sesame	40, 60, 80	10, 20, 30

♦ Fertilizer Trials: The Effect of Nitrogen and Phosphorous Methods of Application on Sorghum:

In the 1983 crop season, phosphorus and nitrogen + phosphorus at 40 and 40+40 kg/ha, respectively, gave significantly higher grain sorghum yields than the untreated checks, whereas nitrogen alone depressed grain yield (Gingrich, et al., 1984). Therefore nitrogen and phosphorus methods of application trials were conducted in 1984 at the Seraaf experimental farm in order to further test the effects of nitrogen and phosphorus on sorghum. Sorghum varieties Gadam El Hamam, Hageen Dura 1, and local (Eryana) were planted in a randomized complete block design with 3 replications. Nitrogen (40 kg/ha) was applied as surface dressing and soil incorporation while phosphorus (40 kg/ha) was applied in the furrow with the seeds at planting time. The objectives of this trial were (1) to verify the effects of nitrogen and phosphorus on sorghum and (2) to determine the effects of nitrogen methods of application on sorghum. For details of experimental design and treatments refer to Kadugli Research Report, Vol. 2 (Woldetatos, 1985).

The results of the fertilizer trials were as follows: all sorghum varieties gave significantly higher grain yields with the application of nitrogen and nitrogen + phosphorus; the seeding vigor rating, plant height, stover weight, and grain yield responses to the fertilizer were in the order N+P>N>P; the response of sorghum to single applications of N and P was opposite to Gingrich's findings, because the 1984 fertilizer trials were conducted on previously fallow land, whereas Gingrich carried out his experiments on cultivated fields (Gingrich, et al. and Woldetatos, 1985); and the results indicated that higher sorghum grain yields were obtained from N soil incorporation than surface dressing. The overall results lead us to the following recommendations:

- (1) Nitrogen should be soil incorporated in order to avoid its loss through volatilization;
- (2) Nitrogen and phosphorus trials be continued in the 1985 crop season at rates of 20, 40, and 60 kg/ha, respectively. Include K and micronutrients if source of fertilizers are available; and

- (3) Soil and plant tissue lab analysis for soil nutrient content and availability for both cultivated and fallow lands be run in order to have a clear picture of the soil fertility conditions.

♦ Soil and Water Management and Conservation Trials:

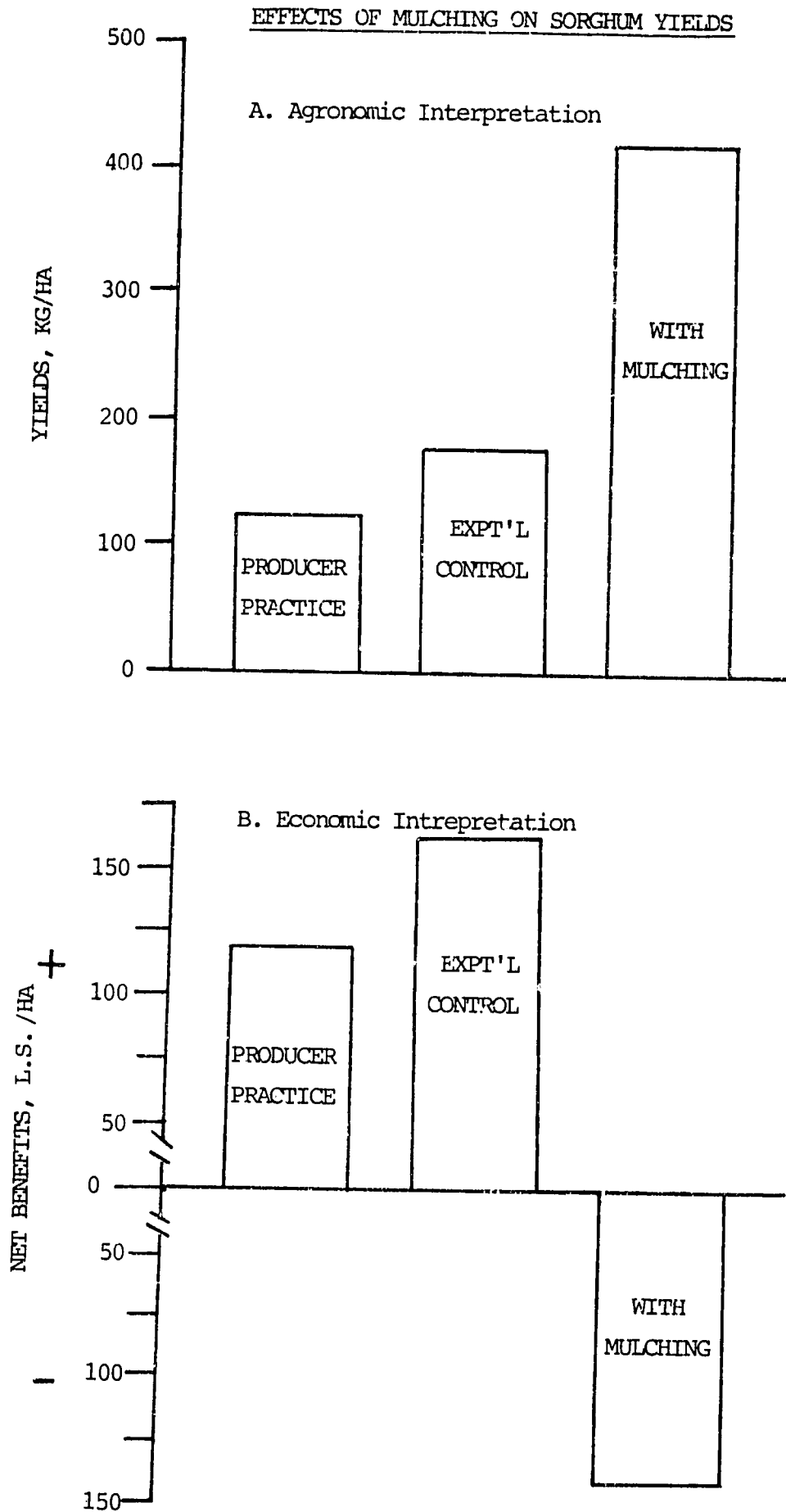
The cracking vertisols are the most important agricultural soils in the Nuba Mountain region. These soils are high in clay (>60%), high in cation exchange capacity (about 57 me/ 100g), low in nutrients and organic carbon (0.3 to 0.7%) with a pH range of 7.4 to 8.4 (GTZ, unpublished report, 1984; Udol et al., 1980; USDA Soil Survey staff, 1975; Gingrich et al., 1984; and Bunderson, unpublished data).

In spite of the high clay content and high moisture-holding capacity the vertisols remain susceptible to drought. These soils crack heavily upon drying and thus promote sub-soil moisture loss through direct evaporation. On the other hand, they expand when wet and the surface gets sealed up, particularly when rainfall intensity is high. The surface sealing leads to reduced water penetration which eventuates the surface runoff of soil and water. Therefore, soil and water management and conservation trials were carried out in Kadugli in order to correct the short-comings of the vertisols. The treatments included and other details are described in the 1985 Kadugli Research Report, Vol. 2.

Results and recommendations from the mulching trials were as follows: the results indicated that mulching retained the highest soil moisture throughout the growing season; the sorghum plants in the mulched plots were significantly taller and eventually gave 2.4 times grain yield and 1.5 times total dry biomass as that of the standard practice (See Figure 2); and in the crop residue management observation trials, the surface chopping of residues retained the highest soil moisture. These results indicate that mulching is a potential solution for the prevailing southbound desertification in the Nuba Mountain region. Therefore, we recommend that:

- (1) similar soil and moisture management and conservation trials be repeated in the 1985 crop season, and
- (2) the benefit/cost ratio be calculated in order to determine its economic feasibility for future intervention.

FIGURE 2



b. Variety Screening and Development Trials

One of the constraints of crop production in the Nuba Mountain region is continuous use of the late maturing and low yielding traditional varieties of the major crops. In the 1983 crop season the rainfall was unusually low and poorly distributed. Under such marginal rainfall conditions, traditional varieties of sorghum and cowpeas failed to produce harvestable heads and pods, whereas the early maturing, improved varieties of sorghum and cowpeas did produce seeds both in the on-farm and on-station trials. Therefore, the objective of the variety trials is to introduce early maturing, disease-resistant, and high-yielding varieties of the major crops to the Nuba Mountain region.

In the variety screening and development trials, the soybean national variety trial and freely modulating soybean trials failed to produce harvestable pods, due to rabbit and blister beetle damage and low rainfall. Similarly, the sorghum-legume intercropping, Hageen Dura 1 seed production, and pearl millet variety trial "8C" failed to produce heads, and therefore, were abandoned from the experiments.

On the basis of overall agronomic merits, 8 varieties of sorghum (Cross 40:36, Cross 34:18, Cross 35:20, Cross 35:5, Cross 54:43, GSA 5552, Cross 43:33 and Cross 54:36), ranging in grain yields from 752 (Cross 40:36) to 307 (Cross 54:36) kg/ha were advanced to the 1985 crop season. In addition, Dabar, Gadam El Hamam, Hageen Dura 1, and a local variety (Eryana) were also advanced to the 1985 crop season. In a yield comparison trial including Hageen Dura 1, Gadam El Hamam, and Eryana, fertilized with nitrogen and phosphorus at a rate of 40 + 40 kg/ha, grain yields were 812, 785, and 785 kg/ha, respectively.

Seven varieties of cowpeas (b 58-57, 58-185, M-66, CB-5, 8047, M-80 and 1-12-3) gave yields of over 300 kg/ha in 1983 and/or 1984 and were advanced to the 1985 crop season. Five varieties of mungbeans (VC 1482 A/VC 1628A, VC 1481 A/VC 1560 A, VC 2388 A/VC 1177, VC 1481 A/VC 1628 A(B), and CES 1D-21/EG mg-16), ranging in grain yields from 684 (VC 1482 A/VC 1628A) to 596 (CES 1D-21/EG m9-12) kg/ha, were advanced to the 1985 crop season. Five varieties of groundnut (PRONTO EM-12, EM-9, TAMNUT, SPANTEX and SPANCROSS), ranging in grain yields from 409 (PRONTO EM-12) to 193 (SPANCROSS) kg/ha; three varieties of sesame (A/5/13, 75116 and A/1/9), ranging in grain yields from 247.0 (A/5/13) to 195.0 (A/1/9) kg/ha; and six

varieties of pearl millet (ISMI 8409 [F4 754], BRISTLED POPN MG BULK, ISMI 8407 [F4 610], ISMI 8402 [F3 422], ISMI 8401 [F3 398] and BULK POPN C₁ BULK), ranging in yields from 441 (ISMI 8409 [F4 754]) to 217 (BULK POPN C₁ BULK) kg/ha, were all recommended to be advanced to the 1985 crop season.

2. ON-FARM TRIALS

a. Farmer-Managed

♦ Effect of Plant Seed Dressing on Sorghum:

The 1983 on-farm and on-station trial results indicate that improved sorghum varieties treated with seed dressing and phosphorus out-yielded local sorghum varieties grown under traditional cultural practices. On the other hand, nitrogen had a depressing effect on sorghum (Gingrich et al., 1984). Therefore, farmer-managed trials on the effect of phosphorus and Aldrex-T seed dressing on sorghum was carried out in 1984 in order to further evaluate the suitability of this intervention agronomically and economically in the Nuba Mountain area. The trial sites were Kululu, Bilenya, and Shaer.

In spite of the unusually low rainfall and poor distribution the improved varieties, Gadam El Hamam and Dabar, with improved cultural practices, consistently out-yielded the local sorghum varieties, with traditional practices, across all locations. In Bilenya, none of the local varieties produced any harvestable heads due to a combination of low rainfall and their late-maturing characteristics. Therefore we recommend that similar trials be continued in the 1985 crop season with the following modifications:

- (1) Plant 1/2 plot of G. Hamam and Dabar at planting time of the local sorghum and the remaining 1/2 two weeks later; and
- (2) advise farmers to do thinning and weeding at 2 to 3 weeks after sorghum emergence.

♦ Hybrid Sorghum Observation Trial:

Twenty-two farmers grew the newly developed hybrid sorghum, Hageen Dura 1, at different sites around Kadugli. The farmers were satisfied with Hageen Dura 1 because it matured earlier and out-yielded the traditional sorghum varieties. In addition, it has an excellent flavor as a food crop. Therefore, it has an excellent potential for future use in the Nuba Mountain area provided the F1 seed is available on time and farmers are

convinced not to use F2 generation as a source of seed for the following season.

b. Researcher-Managed

♦ The Effect of Nitrogen and Phosphorus on Sorghum:

The 1983 research data indicated that sorghum yield was significantly increased due to phosphorus and nitrogen + phosphorus applications at 40 and 40 + 40 kg/ha, respectively, whereas nitrogen had a depressing effect on sorghum. Therefore, the objective of this trial was to investigate the effect of nitrogen and phosphorus under farmers' field conditions. Phosphorus and nitrogen + phosphorus gave 1.6 to 2.0 times grain yield of Gadam El Hamam and Dabar compared to the untreated checks (See Table 2), while inducing 8-11 days earlier flowering. On the other hand, single application of nitrogen decreased sorghum yield. The local sorghum variety did not show any significant response to the fertilizers due to its late-maturing characteristics. These results lead us to conclude that future fertilizer trials should emphasize the use of the early maturing improved varieties of sorghum and delete single application of nitrogen from the fertilizer treatments on farmers' fields under cultivation.

Partial budget analysis was performed on these trial to provide economic guidelines for the Agronomy Section to use in making managerial decisions for future fertilizer trials. The results of this analysis showed a negative yield response to the application of nitrogen and a positive response to phosphorus (see Figure 3). Combinations of nitrogen and phosphorus also showed positive production responses in each trial. Rates of return to variable costs for improved varieties, compared within and among trials, were very high. Rates of return for improved varieties, compared with long-term average yields for South Kordofan, ranged from 268% for Dabar to 404% for Gadam El Hamam. On the basis of these research results, both varieties appear to be candidates for recommendation to producers when a market for inputs is developed. At the present time, fertilizers, seeds and seed dressings are unavailable in the market, due at least partially to government regulations restricting the free market purchase of such inputs.

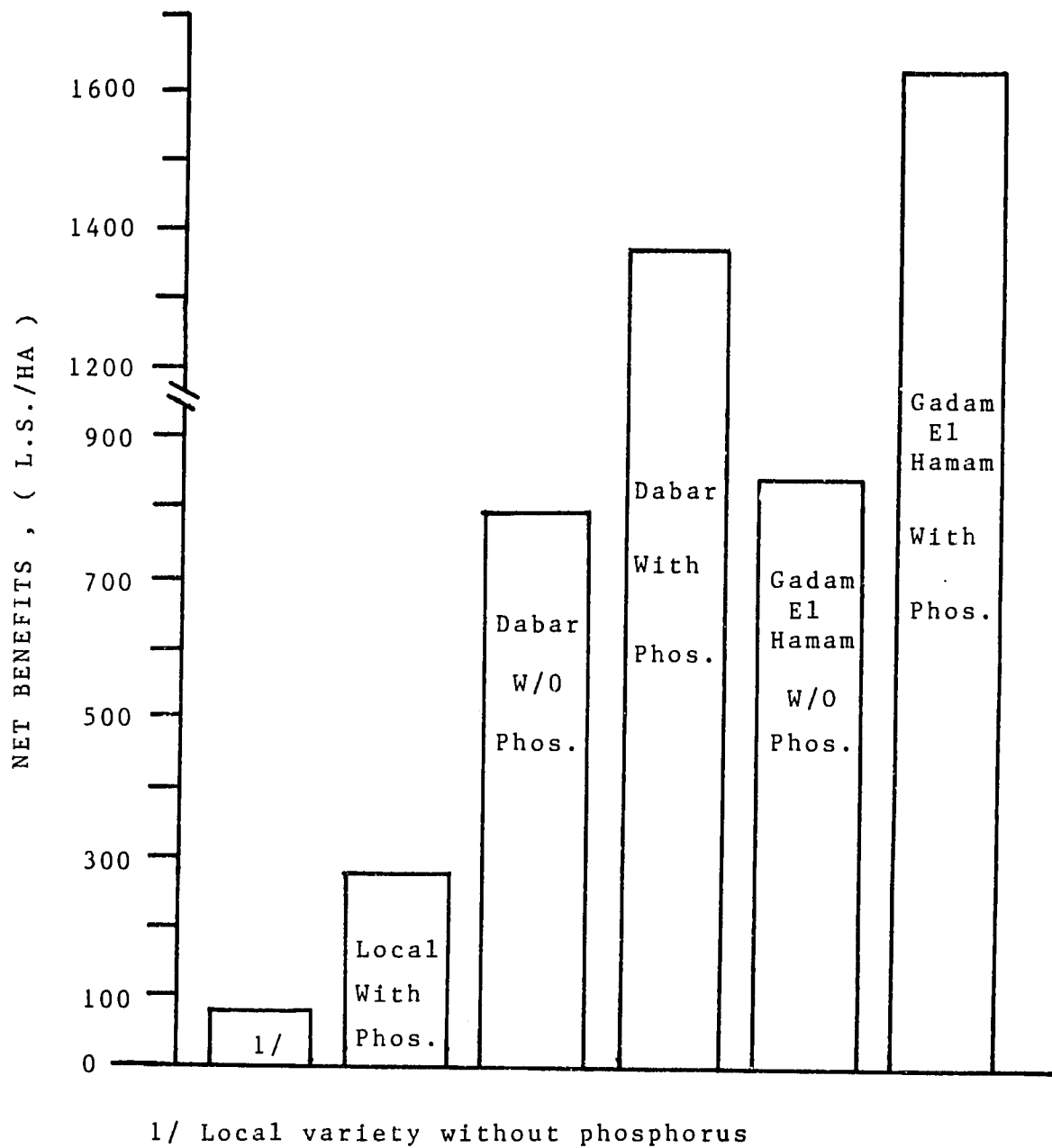
TABLE 2

The Effects of Nitrogen and Phosphorus on Sorghum
Yields (Kululu), 1984

Variety	Treatment N - P		Grain Yield kg/ha
Gadam El Hamam:			
	0	0	840
	40	0	525
	0	40	1765
	40	40	1447
Dabar:			
	0	0	894
	40	0	540
	0	40	1488
	40	40	1692
Local:			
	0	0	92
	40	0	149
	0	40	376
	40	40	390

FIGURE 3

NET BENEFITS (L.S./HA) FROM SORGHUM PRODUCTION
WITH AND WITHOUT PHOSPHORUS FERTILIZER: VARIETIES
GADAM EL HAMAM; DABAR; AND A LOCAL VARIETY, 1984
(KULULU, SUDAN)



♦ The Effect of Timely Practices and Seed Dressing on Sorghum:

The objective of this trial was to determine the effect of seed dressing with Aldrex-T, plant population, timely planting and weeding practices on sorghum. The results showed that Gadam El Hamam and Dabar gave lower yield than the local sorghum with traditional practices at Kululu because the plots were highly infested with Striga and the plant population was too dense for the available rainfall and soil fertility. We recommend that this trial be repeated in the 1985 crop season with proper site selection, early planting, and reduced plant population.

♦ Striga Resistance National Trials:

Striga is one of the most serious limitations on sorghum production and causes enormous losses in sorghum grain yield especially under low rainfall and poor soil conditions. Sometimes it even causes a total failure of sorghum production depending at what growth stage of the host Striga attacks. Therefore, two sets of Striga national trials were conducted in order to evaluate resistance of several lines of sorghum to Striga [Striga hermonthica (Del) Benth].

Among the sorghum lines tested 1S-9830 was the earliest to flower, with relatively low Striga count and high grain yield. Therefore, we recommend that more detailed agronomic work be done on 1S-9830 in the 1985 crop season. Furthermore, we recommend that Striga control trials using varieties and cultural practices be carried out in the 1985 crop season. Suggested treatments would be as shown below:

- (1) Varieties (2) -- resistant 1S9830 and susceptible Dabar;
- (2) Sorghum spacing between rows : 60, 90, 120 cm; and within rows 20,30,40 cm.
- (3) Fertilizers: N, P, and N+P at 40, 40, + 40 + 40 kg/ha;
- (4) Atrazine.

♦ On-Farm Trials for the 1985 Cropping Season:

Farmer-managed trials for the 1985 cropping season will include; (1) Hageen Dura 1 demonstration trials (subject to the availability of seeds); (2) trials on the effects of phosphorus and seed dressing (Aldrex-T) on improved and local varieties of sorghum; and (3) observation trials on improved varieties of sorghum, cowpeas, and groundnut for jubrakas (housegardens). Researcher-managed trials will examine the effects of

nitrogen and phosphorus on the sorghum varieties Dabar, Gadam El Hamam, Hageen Dura 1, and a local variety; the effects of seed dressing and timely practices on sorghum yields; and sorghum and sesame intercropping trials with legumes. In addition, Striga control trials will be initiated using different sorghum varieties in combination with different plant spacings, atrazine, and fertilizer treatments. Several varieties of sorghum that have shown some resistance to Striga will be selected and further tested for their resistance and yield potential.

♦ On-Station Trials for the 1985-1986 Crop Season:

The 1985-1986 on-station agronomy research program will include (1) variety screening and development on sorghum, cowpeas, mungbeans, sesame, pigeonpeas, groundnuts, and maize; and (2) cultural practices trials on (a) nitrogen and phosphorus rate of application effect on sorghum, (b) rate and date of planting trials on sorghum, cowpeas, and sesame, (c) sorghum intercropping with sesame and legumes, (d) weed control trials, and (e) soil and water management and conservation.

C. RANGE-LIVESTOCK RESEARCH PROGRAM RESULTS - 1984/85

Contributing Scientists: Dr. W.T. Bunderson, Range-Livestock Ecologist; Dr. R.H. Cook, Livestock Production Specialist; Dr. T.E. Gillard-Byers, Agricultural Economist; Dr. I. Hashim, Range Scientist

1. INTRODUCTION

Livestock represent an important resource and production enterprise for most of the sedentary producers in the Nuba Mountains. The principal objective of the 1984/85 research program with the sedentary system was to improve the integration of cropping and livestock activities to address the potential for a semi-intensive system of mixed farming. Emphasis was placed on cattle and goats since sheep and swine are kept by fewer producers, and their numbers are relatively low. Although goats are raised by a larger percentage of households, and probably represent the most important livestock in the system, research on these animals is comparatively recent and the results are incomplete at this time. Consequently, attention in this report will center on cattle, focusing on two main areas, the introduction of animal draft, and the use of legumes and crop residues for supplemental animal feed during the dry season.

2. INTRODUCTION OF ANIMAL TRANSPORTATION TECHNOLOGY

Previous researcher-managed/on-farm trials with sedentary producers on the use of animal draft for transporting a variety of agricultural products³ were considered successful on the basis of producer participation and improved labor efficiency. Accordingly, a follow-up experiment was undertaken in Kululu under farmer-managed conditions during the 1984/85 cropping season. Thirteen producers participated in the experiment which focused primarily on the movement of dura (sorghum) heads from the far

³Research conducted by D. W.T. Bunderson, and contained in Bunderson, et al. 1984.

fields to the threshing area. Other activities included the movement of grass straw and grain.

Results of the trial suggested that both community welfare and private benefits accrued from the introduction of the technology in Kululu (See Table 3). Many communities in the area are considered quite homogeneous in comparison with Kululu and should also be capable of using the technology. Benefit cost ratios for the technology ranged from 1.15 in year one to 3.45 in year five when only rental benefits were considered. When welfare benefits which accrued to the community were included, the benefit cost ratios ranged from 4.92 in year one to 11.24 in year five. These results indicated that the introduction of ox-cart transportation is adoptable from the technical perspective and acceptance of the technology on behalf of producers has appeared quite good.

Based on these results, the following recommendation have been made:

- ♦ The Nuba Mountain Rural Development Project located in Kadugli should investigate the possibility of ox-cart sales without requiring the purchase of other implements, which is presently the case.
- ♦ An estimation of the optimal number of ox-carts needed to service a village should be undertaken to prevent initial oversupply of the technology in the market which could lead to marginal returns less than marginal costs for rental activities.
- ♦ The Agricultural Bank of Sudan should provide credit to individuals, as well as, cooperative groups of producers wishing to purchase ox-carts.
- ♦ Benefit/cost ratios suggest that the technology is recommendable. Cooperative efforts on behalf of the Agricultural Extension Departments, the Rural Development Projects, the Regional Ministry of Agriculture and the Agricultural Bank of Sudan should be made to extend the technology to producers in areas where animal traction had not been undertaken previously. Such activities could provide a knowledge base for the future introduction of traction activities and reduce investment costs for future implement purchases.
- ♦ Future research should be undertaken, specifically; (1) the placement of oxen and carts in Nuba Mountain area villages to determine the demand for rental services; (2) make oxen and carts available to villages on a year-round basis to determine the time, type, and quantity of activities; and (3) identify alternative employment and the value of alternatives for women's freed labor.

TABLE 3

POTENTIAL LABOR SAVINGS ASSOCIATED WITH THE ADOPTION OF OX-CART
TRANSPORTATION, KULULU, 1984

Commodity Transported	Ox-Cart kg/load	Human kg/load	Equivalent WD ^{1/} to transport 1 day's ox-cart load	Potential Days of Activity/Yr.	Potential WD ^{1/} Freed/Yr.
Sesame	407	14.4	28.8	30	864
Dura (Sorghum) Heads	508	18.0	26.3	60	1,578
Grass	300	15.0	18.7	45	842

1/ WD = woman day, approximately six hours/day

3. IMPROVED INTEGRATION OF FORAGE CROPS

a. Introduction

Legume crops are currently grown on a limited scale by the Nuba, and consist primarily of groundnuts and cowpeas. Grain yields from these crops are low, and their residues for livestock feed are short in supply and inefficiently utilized.

Specific objectives involving the improved use of legume crops are to maintain or improve soil nitrogen, and to provide a protein supplement to both households and livestock. The results should lead to:

- ♦ improved yields of cereal and oil-seed crops in a system with a longer period of continuous cultivation;
- ♦ an effective shortening of the fallow period;
- ♦ reductions in the relative proportion of land in fallow versus that under cultivation;
- ♦ reduced time and labor costs in clearing new or long-abandoned land;
- ♦ improvements in the grazing quality and utilization of fallow areas;
- ♦ improved diets of households during the "hungry period"; and
- ♦ improved productivity of livestock.

The necessary stages of research for accomplishing these objectives involve both on-station and on-farm research⁴.

b. Screening Trials on the WSARP Station Farm

♦ Rationale:

Promising exotic and indigenous legumes are being screened on the research station to identify well adapted species and varieties for production in the Nuba Mountains. Emphasis is being placed on the cracking clays since this is where the greatest potential lies for cultivation. Desirable characteristics under examination include: abundant vegetative

⁴Bunderson, W.T.. 1985. Kadugli Annual Research Report, Vol. 2

growth and high forage value; good nodulation without the need for inoculum; resistance to drought, insect pests, and disease; and good competitive ability with weeds. Those demonstrating potential for both grain and forage will receive priority and will form the basis for initial interventions. This is because the majority of traditional farmers are reluctant to devote land, labor, and capital for cultivating a forage crop when the activity conflicts directly with the needs of important food and cash crops. There must be a significant economic return from producing legumes other than what is gained through improvements in soil fertility. While dual-purpose legumes currently offer the greatest attraction to traditional farmers, (i.e., there are two harvestable crops of high economic value), legumes used strictly for fodder are also under evaluation since such crops may become equally profitable in the near future. -

Results:

The results of the 1984 trials are summarized in Table 4. The selection of species and varieties for the 1984 screening trials was based on the availability of seeds, good germination results from lab tests and information obtained from the trials of 1983 (Bunderson, et. al, 1984). The 1984 trials also included evaluations of several grass species/varieties to examine the future potential of intercropping legumes with grass to boost overall yields, while maintaining an adequate level of forage quality.

♦ Conclusions and Recommendations:

The results in Table 4 clearly demonstrate the superior performance and adaptability of several legumes and one grass over other species tested (despite exceptionally low and poorly distributed rainfall):

- (1) Phaseolus aureus, (mungbeans - a line obtained locally from the Range & Pasture Administration);
- (2) Cyamopsis tetragonolobus, (guar - a line obtained locally from the ARJ);
- (3) Vigna sinensis, (cowpeas - a line obtained locally from traditional farmers);

TABLE 4 SUMMARY OF FORAGE SCREENING TRIAL RESULTS 1984

SPECIES AND VARIETIES	% LAB GERMIN.	D.M. YIELD (KG/HA)	NODULE PROD.	ADAPTABILITY				SEED PROD.	RAINFALL (PLANT TO HARVEST)
				SOILS	DROUGHT	INSECTS	DISEASE		
<i>Desmodium intortum</i>	71%	-	-	Poor	Poor	N/A	N/A	None	No Harvest ¹
<i>Macroptilium atropurpureum</i>	84%	490.4	Fair	Good	Good	Good	Fair	Fair	208.9
<i>Phaseolus trilobus</i>	81%	1006.5	Excell.	Excell.	Excell.	Excell.	Excell.	Good	198.7
<i>Centrosema pubescens</i>	61%	320.5	Fair	Fair	Good	Fair	Good	None	200.7
<i>Glycine wightii</i> (Tinaroo)	82%	-	-	Poor	Poor	N/A	N/A	None	No Harvest ¹
<i>Dolichos lablab</i> (Bag #1)	100%	792.6	Fair	Good	Excell.	Excell.	Excell.	None	198.7
<i>Stylosanthes scabra</i>	89%	-	-	V. Poor	Fair	N/A	N/A	None	No Harvest ¹
<i>Vigna radiata</i> (Local)	95%	1805.8)	Excell.	Excell.	Excell.	Excell.	Excell.	Excell.	198.7
<i>Clitoria ternatea</i>	90%	2168.4)	Excell.	Good	Excell.	Fair	Excell.	Excell.	200.7
<i>Stylosanthes humilis</i>	96%	-	-	Poor	Fair	N/A	N/A	None	No Harvest ¹
<i>Vigna sinensis</i> (An Garko)	79%	1027.5	Excell.	Excell.	Excell.	Good	Excell.	Good	198.7
<i>Dolichos lablab</i> (Bag #2)	100%	727.5	Fair	Good	Excell.	Excell.	Excell.	None	198.7
<i>Cyamopsis tetragonoloba</i>	55%	1482.2	Good	Excell.	Excell.	Excell.	Excell.	Excell.	200.7
<i>Desmodium uncinatum</i>	49%	-	-	V. Poor	Poor	N/A	N/A	None	No Harvest ¹
<i>Stylosanthes guianensis</i>	27%	-	-	V. Poor	Poor	N/A	N/A	None	No Harvest ¹
<i>Vigna sinensis</i> (Local)	100%	1085.0	Excell.	Excell.	Excell.	Fair	None	Poor	198.7
<i>Vigna radiata</i> (Texas)	82%	569.2	Good	Excell.	Excell.	Excell.	Excell.	Excell.	156.7
<i>Sesbania exaltata</i>	90%	-	-	Good	N/A	V. Poor	N/A	N/A	No Harvest ³
<i>Dolichos axillaris</i>	60%	-	-	Poor	Poor	Good	Good	None	No Harvest ¹
<i>Glycine wightii</i> (Cooper)	20%	-	-	Poor	Poor	Good	Good	None	No Harvest ¹

1 Not harvested due to extremely poor performance and expected yield

2 Not harvested due to insufficient rainfall from August to October and late planting, resulting in negligible yield

3 Not harvested due to destruction of plants by blister beetles

TABLE 4 SUMMARY OF FORAGE SCREENING TRIAL RESULTS 1984 (Cont'd)

SPECIES AND VARIETIES	% LAB GERMIN.	D.M. YIELD (KG/HA)	NODULE PROD.	ADAPTABILITY				SEED PROD.	RAINFALL (PLANT TO HARVEST)
				SOILS	DROUGHT	INSECTS	DISEASE		
Crotalaria Sp. (An Garko)	93%	1824.2	Fair	Excell.	Excell.	V.Poor	Excell.	Excell.	185.2
Dolichos lablab (Bag #3)	96%	343.6	Fair	Excell.	Excell.	Excell.	Excell.	None	85.4
Lablab purpureus (Highworth)	88%	521.2	Fair	Excell.	Excell.	Excell.	Excell.	None	85.4
Lablab purpureus (Rongai)	91%	379.6	Fair	Excell.	Excell.	Excell.	Excell.	None	85.4
Vigna sinensis (K30)	96%	-	-	Excell.	Excell.	Fair	Good	Poor	No Harvest ²
Vigna sinensis (Local)	100%	-	-	Excell.	Excell.	Good	Good	None	No Harvest ²
Clitoria ternatea (Bag #2)	90%	-	-	Good	Excell.	Fair	Excell.	None	No Harvest ²
Crotalaria Sp. (2nd Plot)	93%	-	-	Excell.	Excell.	V.Poor	Excell.	None	No Harvest ³
Cyamopsis tetragonobola (2nd Plot)	84%	-	-	Excell.	Excell.	Excell.	Excell.	Good	No Harvest ⁴
Macroptilium atropurpureum (Bag 2)	56%	-	-	Good	Good	Excell.	Good	Fair	No Harvest ⁴
Desmodium uncinatum (Bag #2)	75%	-	-	Poor	Poor	N/A	N/A	None	No Harvest ¹
Dolichos lablab (Bag #4)	100%	-	-	Excell.	Excell.	Excell.	Excell.	None	No Harvest ⁴
Pioneer Grass 988 (Hybrid)	85%	1795.1	None	Excell.	Excell.	Excell.	Excell.	Poor	158.7
Columbus Grass (Sorghum sp.)	68%	-	None	Fair	Good	Excell.	Excell.	Fair	No Harvest ²
Panicum maximum (Green Panic)	22%	-	None	N/A	V.Poor	N/A	N/A	None	No Harvest ¹
Cynodon dactylon	31%	-	None	N/A	V.Poor	N/A	N/A	None	No Harvest ¹

1 Not harvested due to extremely poor performance and negligible yield

2 Not harvested due to insufficient rainfall from August to October, and late planting, resulting in negligible yield

3 Not harvested due to destruction of plants by blister beetles

4 Not harvested due to expected yields similar to previous yield of the same legume

- (4) Vigna sinensis (Cowpeas - a line obtained locally from the Range and Pasture Administration in Kadugli, and produced at An Garko 20 km south of Dilling);
- (5) Phaseolus trilobus (Phillipāsara - a species obtained locally from the ARC);
- (6) Clitoria ternatea (Butterfly Pea - a line obtained from the ARC and the Range Administration in Khartoum); and
- (7) Pioneer Grass Hybrid 988 (A sorghum-Sudan grass hybrid obtained from Texas).

Of the above, mungbeans, guar, and cowpeas all show high potential for grain as well as forage. The resin from guar can also be used as a commercial cash crop. These three species out-yielded the best performing forages, namely Clitoria and Phaseolus trilobus, although the latter are expected to provide better yields with improved spacing and earlier planting. In general, the plant spacing used for many species was too close, and the seed rate too high. Future trials (see below) should examine this to determine optimum levels. Several additional species gave reasonably good yields, but had problems in other respects. (See Table 4).

Future research on legumes should give priority to those which produce grain for human consumption as well as a significant amount of good quality forage. Based on the results of the past two years, attention should be focused on mungbeans, cowpeas, guar, and pigeon peas. The latter were not grown in experimental plots in 1984 due to the fact that the few seeds available were used in a researcher-managed experiment with Nuba farmers in the Kululu area (Woldetatos, 1985). In addition, work should also continue on screening new forage legumes and examining optimum planting procedures for those already showing high potential. Details regarding recommendations are discussed in Vol II of the 84/85 Annual Report.

It is important that proper germination tests be carried out for all research on legumes because we have experienced considerable problems with non-viable seed in the past. It is anticipated that with improved plant spacing and/or seed rates, yields of all promising legumes will increase by 100-150% under more normal rainfall. Research on grass species should also terminate since grass is locally abundant in the region, and any improvement in quality is not likely to be cost effective. Moreover,

farmers will be extremely reluctant to cultivate grasses over legumes, particularly with no product for human consumption.

c. Forage Production Trials on the WSARP Station Farm

♦ Rationale:

The principle purpose of these trials was to produce a sufficient quantity of high quality forage for use in several feeding trials with native cattle.

The trials are expected to establish and demonstrate the potential benefits of feeding legume hay to productive breeding stock during the late dry season when nutritional stress on these animals is at its peak. Details concerning these feeding trials are provided by Bunderson & Cook and Hashim & Bunderson in subsequent sections of this report.

♦ Results:

Yields for the cowpeas, Clitoria ternatea, Phaseolus trilobus, and Pioneer Grass were satisfactory, given the amount of rainfall received (i.e., 97.2 - 136.2 mm from the time of planting to harvest). This provides further support that these three legume species are suitably adapted to this region, and should perform satisfactorily under more normal rainfall, particularly with earlier planting and proper plant spacing.

♦ Conclusions and Recommendations:

Due to severe constraints associated with hand labor in producing the large quantities of forage required for extensive feeding experiments, such activities should only be done with the assistance of the mechanized implements. These should include a 70-100 HP tractor, equipped with a disc or chisel plow, a disc harrow, a grain drill or seeder with adjustments for different sized seeds, and a mower for harvesting. It is also likely that additional land will be required for this activity on the agronomy research farm, and preparations should be made to clear new land adjacent to the eastern boundary. Legume species currently recommended for large scale production at this point in time include Phaseolus trilobus, Clitoria ternatea, local cowpeas, and mungbean variety obtained from the ARC in Wad Medani. Seeds for all of these legumes are usually readily available in Sudan, but continued use of them for forage should rely on our own propagation programs. Seeds from other forage/legume trials should also be

saved for subsequent seasons rather than depend on expensive and difficult purchases from overseas and other parts of Sudan.

d. Researcher-Managed On-Farm Trial at Kululu

♦ Rationale:

This trial was part of a larger experiment designed to demonstrate a crop rotation system using legumes as sole and intercrops for traditional cultivation on the cracking clays. Details of the entire experiment are presented in Woldetatis (this report). The legumes were planted to address the problem of soil fertility, while simultaneously providing high quality food for both the household and livestock. Species of legumes used in a four-plot rotation included:

- (1) Pigeon peas as an intercrop with traditional sorghum varieties - 1 1/2 feddans;
- (2) Cowpeas (local variety) intercropped with sesame - 1 1/2 feddans;
- (3) Cowpeas (local variety) intercropped with hybrid sorghum - 1 1/2 feddans; and
- (4) Cowpeas (local variety) as a sole crop - 1 1/2 feddans.

For the purposes of this experiment, only the sole crop of local cowpeas was to be used for fodder. The other legumes grown as intercrops were to be harvested only for their grain.

♦ Results:

The harvest of the cowpea plot yielded an average of 1.3 tons/ha of dry forage based on four randomly selected plots, each 10m X 1m in size. Total rainfall received from planting to harvest averaged 290mm. The relatively low yield of forage obtained for the amount of rainfall received was attributed primarily to the excessive plant spacing (i.e. 50cm x 50cm).

Although grain production was not measured, it was low with an estimated 30-50 kg/ha.

♦ Conclusions and Recommendations:

Substantial improvements in the forage yields of local cowpeas can be expected with earlier planting (i.e., June 15-30), and a plant spacing of 50 cm between rows, and 20 cm between plants within the row. Under this planting arrangement, and an effective rainfall of 350-500 mm, forage yields of cowpeas should range from 2.5 - 3.0 tons/ha.

Based on these results, the agronomy, range, and socioeconomic sections of the station agreed that crop rotation systems, such as that used here, were inappropriate as an attractive cost-beneficial intervention for traditional producers in the region.

Future research on legume interventions should be based on intercropping with sorghum and sesame, with the beans serving as the principal crop from the legume, and the forage as a by-product. A comparison of the estimated costs and benefits of legume sole cropping vs. intercropping is presented in Bunderson, Vol I, 84/85 Annual Report. The results clearly demonstrate the economic advantages, in terms of labor, land, and capital, of improved legume intercropping with cereal and oil-seed crops. Recommended trials are given in the report cited above.

e. Overall Conclusions

Legumes grown strictly for forage have little or no economic attraction to traditional producers, and legume monocropping cannot compete favorably with local cultivation practices. However, intercropping dual-purpose legumes with indigenous cereal and oil-seed crops offers distinct and direct economic benefits to both crops and livestock over traditional practices.

With proper execution and extension, successful efforts to more efficiently integrate legumes with traditional agricultural practices should ultimately lead to a system of continuous cropping with significant improvements in the productivity and diversification of traditional crop and livestock activities. Given the importance of the traditional rainfed sector to overall agricultural production in the country, the outcome should contribute substantially to self-sufficiency for food and foreign exchange earnings at both the regional and national level.

3. CATTLE IN-HERD FEEDING TRIALS, 1984

a. Introduction

Preliminary surveys of both the range and animal resources in the area revealed that livestock production in the Nuba system was seriously

affected by nutritional deficiencies during the dry season. Diagnostic studies were subsequently undertaken to help pinpoint the exact nature of the problem in terms of:

- ♦ the overriding, or key nutritional factors involved;
- ♦ the period(s) most limiting to the animal;
- ♦ the class of animal most affected (age, sex, and physiological state);
- ♦ the resulting impact on herd productivity; and
- ♦ the cause-effect relationship of the problem.

Clarification of these factors was considered essential for designing interventions which would effectively alleviate production constraints. Studies conducted in this context included assessments of grazing conditions, and of cattle productivity and management (see Bunderson, et al., 1984).

Results of these studies showed that cattle probably suffered the greatest nutritional stress of the animal species raised. Of the options available for reducing nutritional constraints, supplementation had a clear practical advantage. Other alternatives involving improvements and development of communally-used resources (eg., grazing management systems, range and pasture improvement, fire control, etc.) were not considered viable under the current system of land use. This is due to the inability of producers to implement the necessary management over the resource base to achieve the desired objective (see Section III: Range Evaluation & Land Use).

b. Selection of Potential Supplements

Sources of supplemental feed were evaluated to determine the most practical and cost-beneficial intervention for reducing nutritional stress on cattle survival and productivity. Supplements considered included sesame-seed cake, legume hay, sorghum crop residues, and harvested hay from the native pastures.

The initial selection focused on the latter because of the cheap, abundant, and relatively high quality forage available, at least during the growing season. Efforts to conserve hay therefore appeared to have an attractive cost/benefit ratio over alternative supplements.

c. Results

Chemical analysis of the hay fed showed nutrient contents considerably below the expected values, (i.e. 4.4% crude protein vs 6-8%; 45% TDN vs 50-55%). Data on changes in weight showed no difference in weight loss between the control and supplemental groups at the 99% confidence level. This was not surprising given the quality of hay available. This compares with an experiment in 1983 with non-lactating, non-pregnant cattle, in which the hay-supplemented group lost a significant 33% less weight than the control (Bunderson et al., 1984). Further support for the results of the 1984 experiment is provided by data on the dry matter consumption of hay. This shows an average hay intake of 2.5 kg/animal/day, which, at a crude protein content of 4.4%, would supply only 30% of the total protein required by 225 kg lactating cows producing 1 kg of milk/day. Adding this quantity to that ingested through normal grazing produces a protein deficit of 45% for lactating cows during the last two months of the dry season.

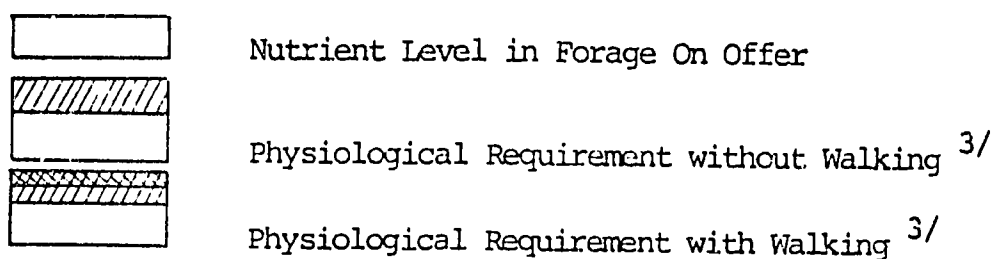
d. Conclusions and Recommendations

Preliminary estimates of the limiting nutrients, critical period of supplementation, and class of animal to feed, still appear valid (see Figure 4). In terms of quality, the bottom-line for an adequate supplement is 6-8% crude protein with a TDN of 52-55%. The basic constraints in producing adequate quality hay from native rangeland were the time and labor required to hand harvest and store early-maturing pastures at a stage of peak nutritive value, without risk of spoilage by rain during the last 30-40 days of the wet season. Under current conditions, the production of adequate quality hay would require considerable capitalization to ensure an early, timely harvest and safe storage from rain. Such an enterprise is presently beyond the capabilities of traditional producers in the Nuba Mountains. Given this situation, native hay is not recommended for future feeding trials, but alternative supplements are under investigation. These are shown in Table 5 along with the associated costs to meet the crude protein needs of 225 kg lactating cows. Based on this assessment, and on our previous experiences, cowpea hay, and/or its combination with sorghum stover, offer the greatest attraction for supplementation. Adaptive research trials are examining the potential for producing forage and grain legumes on a larger scale than presently exists in the region. The

LEGEND

FIGURE 4

COMPARISON OF DRY-SEASON FORAGE ^{1/} LEVELS OF METABOLIZABLE
ENERGY, CRUDE PROTEIN, AND PHOSPHORUS WITH PHYSIOLOGICAL
REQUIREMENTS ^{2/}



1/ Nutrient levels were calculated using average values for the post-flowering stage of grasses common to dry-season grazing areas. Total dry matter intake (DMI) was assumed to be 1.5% of body weight (Fadlalla, 1984, unpublished results). This value is consistent with a 20 - 25% reduction in food intake calculated from the decreased time available for grazing in the dry-season (see text).

2/ Nutrient requirements were calculated for a 250 kg. cow, growth = 0.25 kg./day and milk production = 4.0 kgs/day, from Kearls, 1984.

3/ energy expenditures for walking were calculated at $2.0 \text{ J kg}^{-1} \text{ m}^{-1}$, Hall and Brody, 1934.

FIGURE: 4

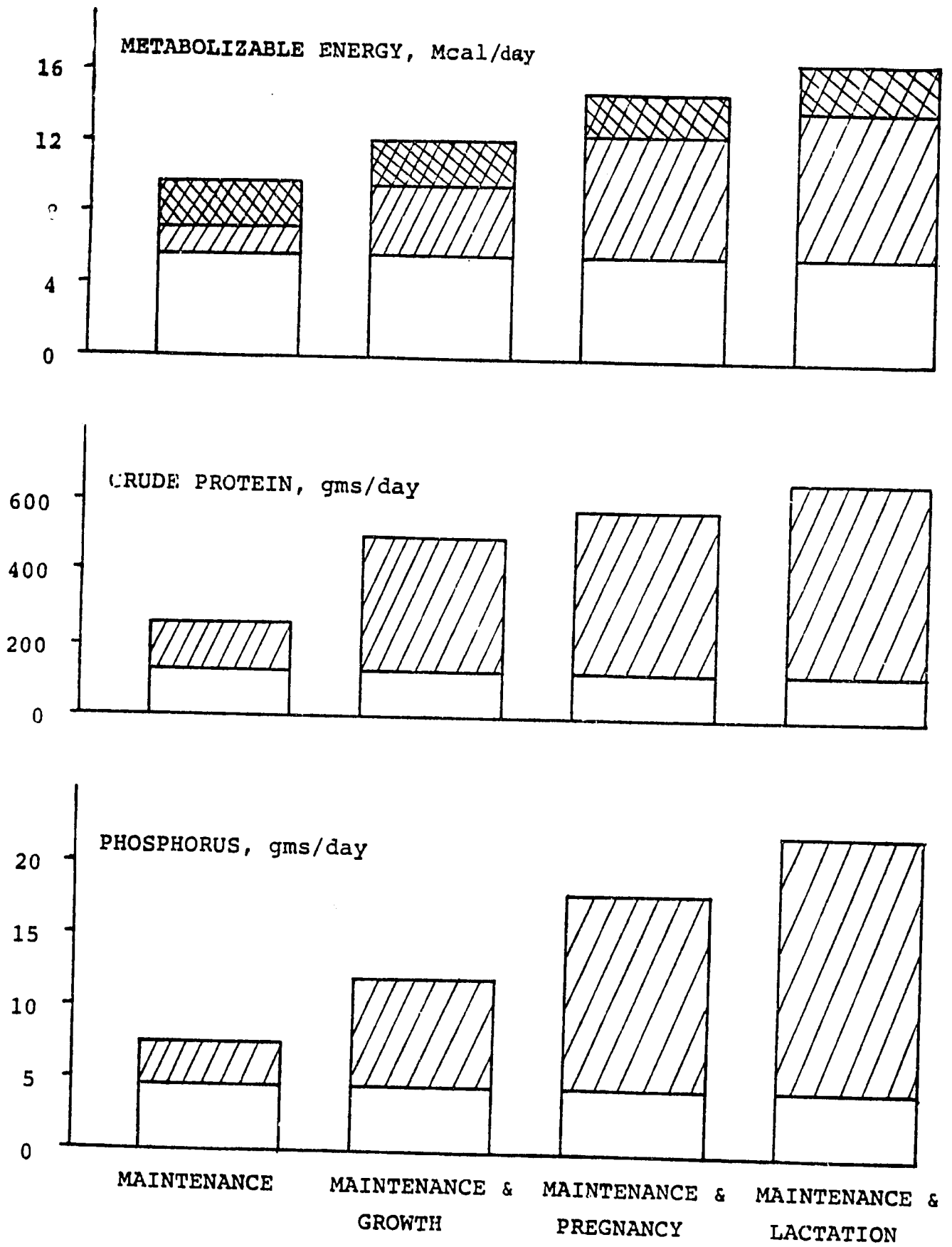


TABLE 5 SUPPLEMENT OPTIONS AND COSTS TO MEET CRUDE PROTEIN
NEEDS OF 225 KG LACTATING COWS PRODUCING 1 KG MILK/DAY

POSSIBLE SUPPLEMENTS AND LEVEL FED/DAY * (MAXIMUM 3 KG/DAY)	TOTAL ME SUPPLIED WITH GRAZING (% OF NEEDS)	TOTAL P SUPPLIED WITH GRAZING (% OF NEEDS)	SUPPLEMENT COST /ANIMAL/60 DAYS
Sorghum Stover 1.7 kg) Cowpea Hay 1.3 kg)	120 %	107 %	S£ 13.92
Grass Hay 1.6 kg) Cowpea Hay 1.4 kg)	110 %	100 %	S£ 13.20
Sorghum Stover 2.6 kg) Sesame cake 0.4 kg)	119 %	111 %	S£ 26.16
Grass Hay 2.6 kg) Sesame Cake 0.4 kg)	105 %	83 %	S£ 24.60
Cowpea Hay 1.9 kg	100%	95 %	S£ 11.40
Sesame Cake 0.7 kg	72 %	86 %	S£ 29.40

* Nutrients required from the supplement are 276 gms C.P.; 4.59 Mcal of ME; 6.38 gms P
Nutrients supplied from grazing at a maximum dry matter intake of 3.0 kg/day are
90 gms C.P.; 4.51 Mcal of ME; and 3.92 gms Phosphorus

** Individual supplement costs/kg are S£ 0.05 for Grass Hay; S£ 0.06 Sorghum Stover;
S£ 0.10 Cowpea Hay; and S£ 0.70 Sesame Seed Cake

principal constraint is to reduce or eliminate direct conflicts with the needs of other cropping activities. Current efforts demonstrate the extremely low production costs of cowpea hay when the legume is intercropped efficiently with sorghum or sesame, and when full use is made of the bean as a subsistence/cash crop (see Section on Improved Integration of Forage Crops).

In addition to trials on legume intercropping and supplementation, research is evaluating (1) methods to reduce conflicts in labor use between forage production and food/cash crops, and (2) improvements in the design and construction of ox-drawn carts to better integrate crop and livestock activities through a more cost and labor efficient harvest of crops and their by-products.

4. CATTLE IN-HERD FEEDING TRIALS, 1985

a. Introduction

Several attempts are underway to reduce nutritional constraints in cattle during the dry season (see Feeding and Legume Trials, this report). The most cost-beneficial appears to involve the use of legumes produced from traditional cultivation in the region. However, since legumes are currently grown on only a limited scale, improvements in the production of dual-purpose legumes are needed before legume forage is readily available as livestock feed. This issue is discussed in the previous section and is dependent on an efficient integration of legumes in traditional crop and livestock production.

The supplement consisted of groundnut and cowpea hay with sorghum stalks fed at a ratio of 3:2. The justification for such a supplement is the high availability and low cost of the supplement compared with potential alternatives. The quality of the supplement is also sufficient to meet most of the protein and energy requirements, as well as the phosphorus needs of lactating and pregnant animals. (The latter were included because of their equal importance to the herd, and similarities in nutritional stress).

b. Results

Only preliminary data are available since this experiment should continue for 3 seasons. Due to a shortage of groundnut hay, the supplement period was reduced to 43 days and fed at 1.6 kg/animal/day. Limited station resources also precluded activity and dietary studies, though these are vital to a proper evaluation of the trial. Such difficulties must be overcome during the remaining two years of the experiment.

Throughout the supplement period, the groundnut hay offered was completely consumed, but only an average of 0.24 kg of sorghum stalks were eaten per animal on a daily basis. At these rates, the supplement would provide approximately 40% of the total protein requirements of a 225 kg lactating cow producing 1 kg of milk/day (assuming a 9% crude protein content for groundnut hay, and 4% for sorghum stalks). For supplemental animals, normal grazing was estimated to supply 25-35% of the protein needs, leaving a deficiency of 25-35%.

A preliminary comparison of weight changes is shown in Table 6 for adult cows. In the Nuba herd, lactating supplemented cows lost 191% less weight than the control group. In the Baggara herd, supplemented lactating animals lost 46% less weight than the control. For pregnant animals which had not calved during the supplement period, the Nuba supplemented group gained 117% more weight than the control. For the Baggara herd, only control animals were present in this physiological class, so no direct comparison within the herd could be made, but they lost 1% of their body weight compared with a 5% gain in the Nuba supplemented group. In the Nuba herd, there were no pregnant cows which had calved during the supplement period; in the Baggara herd only supplemented animals were present in this class, and these lost 13.8% of their body weight. At least half of this loss is attributed directly to the birth of the calves.

The analysis of weight change (for calves) is not complete owing to several deaths and illnesses which occurred in the supplemented and control groups of both herds. Until the causes of calf mortalities are determined, along with any difference in the quantity of milk consumed, the effect of cow supplementation on calves cannot be assessed. However, a preliminary evaluation of calves which survived through the supplement period shows an 8.2% loss of weight among Nuba calves for dams that were supplemented, vs a 6.8% loss for the control. By contrast, the calves of the supplemented

Table 6: Weight Changes of Supplemented and Control Groups, In-Herd Trial 1985

Physiological Class	Nuba Herd		Baggara Herd	
	Supplemented (% Weight)	Control (% Wt)	Supplemented (% Weight)	Control (% Wt)
Lactating Cows	-4.4	-12.8	-9.5	-13.9**
Pregnant (no. births during supplement period)	+5.0	+2.3	---*	-1.0
Pregnant (with births during supplement)	---*	---*	-13.8	---*

* No animals in this physiological class during the supplement period for this group.

** This weight change does not include two cows which were seriously ill and near death, and which consequently could not be weighed.

dams in the Baggara herd gained an average of 47.8% of their body weight compared with only 9.7% in the control.

Again, the interpretation of these differences must await a more thorough investigation of the causes of mortality, and of the quantity of milk allowed for the calves. Likewise, the overall benefits of supplementation must be evaluated after at least 3 years to determine the impact on calving intervals, milk yield, calf growth, age at first calving, and mortality for both adults and calves.

d. Conclusions

The experiment was not entirely satisfactory for this season due mainly to a shortage of legume hay, and to constraints in station resources. However, the results suggest potential for substantial benefits through supplementation with legume forage. It is recommended that the experiment be continued for at least 2 years to provide conclusive results on the costs and benefits of this type of supplementation. The following modifications in the experiment are also recommended:

- ♦ legume forage should be produced and fed in sufficient quantity to provide 70-75% of the total protein requirements of lactating and late pregnant cows for a 60 day period from April 1 - June 1;
- ♦ sorghum stover should no longer be fed as part of the supplement due to the relatively high cost of harvesting and storage for the benefits received;
- ♦ the same animals should be involved in the experiment, but with an additional 5 cows in each supplemented and control group for both lactating and pregnant animals; and
- ♦ an examination of the grazing conditions and diet of the animals should be made at the beginning and end of the supplement period in terms of:
 - (1) total dry matter intake;
 - (2) diet (as determined by the bite-count method or fecal analysis);
 - (3) amount of time available for, and spent, grazing; and
 - (4) distances walked for forage and water.

The latter study is important because factors (1) through (4) vary considerably on a location-specific basis, as well as between physiological

classes of animal. Information on these factors is necessary not only to determine deficiencies in the grazing diet, but what the causes are and how management can be designed to most efficiently overcome these deficiencies.

D. DIAGNOSTIC ACTIVITIES AND DATABASE DEVELOPMENT 1984/85

Contributing Scientists: Dr. T.E. Gillard-Byers, Agricultural Economist; Mr. M. Abu Sabah, Sociologist

Diagnostic activities and database development have been undertaken by the socioeconomic section to provide sociocultural, production, marketing, labor, and food consumption information to assist in the planning, design, and prioritizing of future research activities. Most activities are on-going and provide all station scientists with important longitudinal data which reflect the dynamic interrelationship among the various components of the sedentary production system in the Nuba Mountains.

1. LABOR ALLOCATION

Labor bottlenecks are an important production constraint for sedentary producers. An analysis of labor inputs, by crop or intercrop, was carried out during the 1984-1985 cropping season. Producers in three villages; Kululu, Katcha, and Dobeibat, all located in South Kordofan, were randomly selected to participate in the year-long survey.

Labor requirements for Nuba producers, as represented by the villages of Kululu and Katcha, could be divided into three general groupings: (1) family labor, consisting of adults and children; (2) hired labor, generally consisting of adults; and (3) nafir (communal work groups), also consisting of adults. A similar grouping existed for the Arab farmers in the village of Dobeibat; however, the reliance on nafir labor was quite limited in comparison with the Nuba of Kululu and Katcha. Furthermore, Dobeibat producers participated with the Nuba Mountain Agricultural Production Corporation (NMAPC). The NMAPC provided limited tractor power for cultivation prior to planting and inputs for the production of cotton, which was grown under a contractual agreement between farmers and the NMAPC. Labor for all activities, with the exception of tractor cultivation, was provided by the local labor force using traditional tools and methods of production.

Within this farming system are two major production areas, the far fields (cracking clay vertisols) and the jubraka (housegardens) located on

the sandy footslopes of jebels, (mountains located near the home). The major characteristics distinguishing one area from the other, in addition to location and soil type, are the composition of the labor inputs and the varieties of crops produced (Abu Sabah, 1985). Another important difference is the production objective for each area. Jubra production is meant to be consumed during the "hungry period" which occurs between July and October, whereas the production from far fields is used as a food source for the remainder of the year and surplus marketed to generate cash.

The household labor resources for jubra and far field crop production are illustrated in Figure 5. In Kululu, Katcha, and Dobeibat, women supplied 67%, 45% and 39%, respectively, of the total family labor employed in jubra production activities. The amount of labor supplied for jubra production in the Nuba household was greater than in the Arab households of Dobeibat. The total family labor expended on jubra production in Kululu and Katcha was 120 LD⁵ and 105 LD, respectively. A large amount of child labor was also employed in jubra activities. In Katcha this labor input accounted for the same number of LDs as the adult male labor input of 29 LDs.

No hired or na labor was employed by participants from Dobeibat for jubra production. In Kululu and Katcha both labor sources were heavily relied upon to insure the success of the cropping activities.

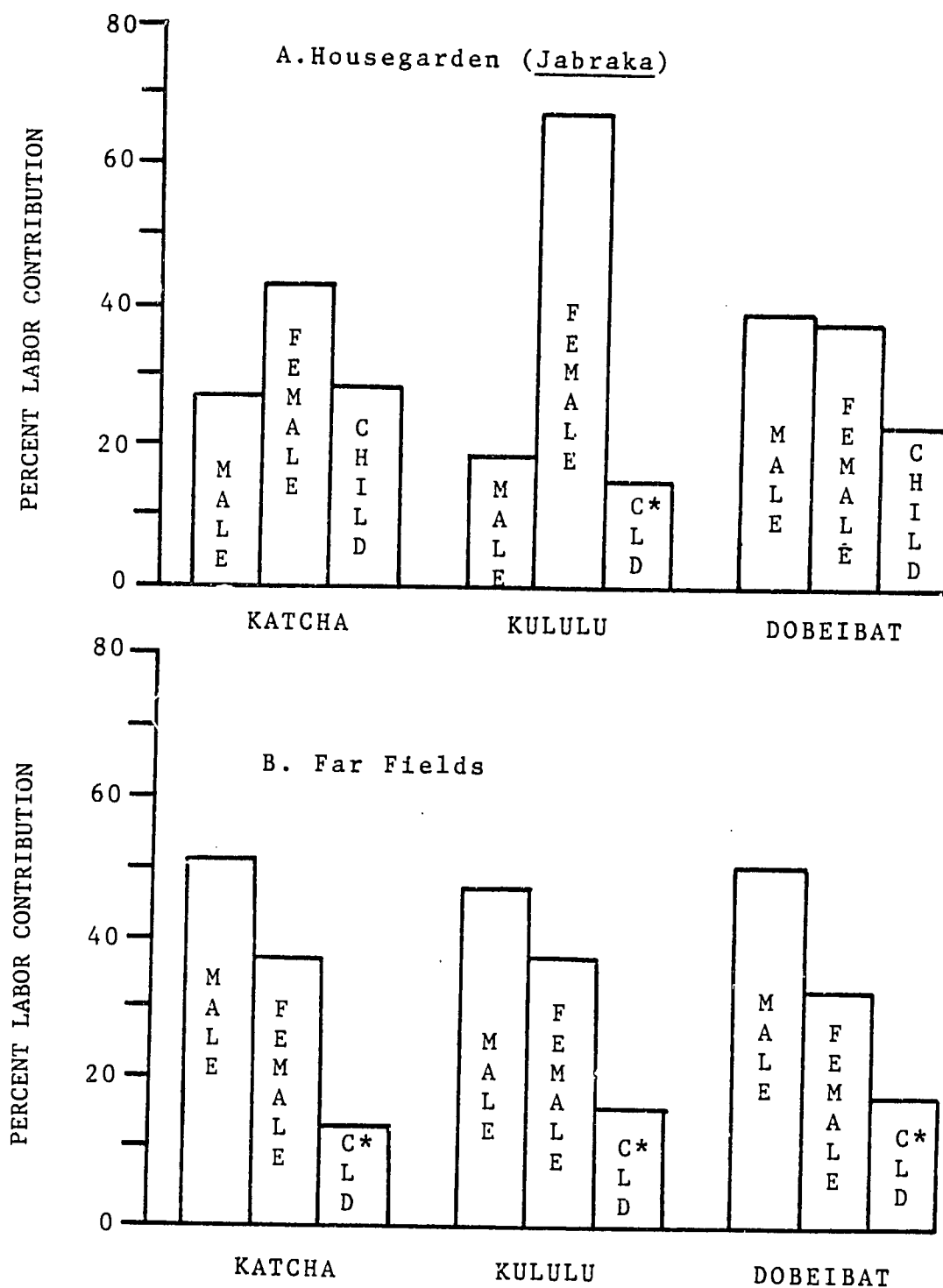
The far field labor allocation differed from that of the jubra in that the majority of the household labor force was provided by adult males (See Figure 4). The major production activity on the far fields in Kululu and Katcha involved the production of sorghum intercropped with cowpeas and/or sesame. In Dobeibat, far fields were generally monocropped to sorghum, the single most labor intensive crop.

In Kululu, 175 LD were spent in the production of the sorghum intercrop by family members. Male labor accounted for 47% of the total labor activity, female labor 37%, and child labor 16%.

⁵One labor day (LD) is imputed to equal one man-day. One man-day is equal to one-woman day and two child-days, about 6hrs/day.

FIGURE 5

HOUSEHOLD LABOR ALLOCATION FOR CROP PRODUCTION
ON HOUSEGARDENS (JABRAKAS) AND ON FAR FIELDS
IN THREE VILLAGES IN THE NUBA MOUNTAIN AREA



*- Child labor

Dobeibat sorghum production was of a similar labor composition with male, female, and child labor providing 50%, 33%, and 18% of the labor input, respectively.

Cropping activities undertaken by households in the three villages included the following:

- ♦ Jubraka Production - short-maturing varieties of sorghum, cowpeas, and sesame, maize, groundnuts, karkadeh (roselle), and vegetables such as pumpkin, tomatoes, cucumber, and watermelon
- ♦ Far Field Production - long-maturing varieties of sorghum, sesame, and cowpeas, karkadeh, cucumber, and for some farmers, cotton.

2. JUBRAKA DIAGNOSTIC SURVEY

Jubrakas, or housegardens, form an integral part of the production activities of the sedentary production system in the Nuba Mountains. The main production objective of jubraka cultivation is to provide households with food security during the hungry period which occurs from July⁶ until the first harvests from the far field in October. Located near the home on light, coarse textured soils, jubrakas are generally from 1/2 - 1 feddan and are efficiently utilized to provide a wide range of harvestable crops, generally for household consumption, though there appears to be an increasing tendency to commercialize. The most important crops grown on the jubraka are early-maturing sorghum, maize, groundnuts, sesame, pumpkin, and other assorted vegetables. In addition, its location and relative ease of cultivation, when compared with the cracking clays of the far farms, provide an opportunity for a wide spectrum of family members to participate in jubraka cultivation, though women would appear to supply the largest percentage of the required labor input. Jubraka harvests generally provide households with at least one third of total consumption requirements. Animal manure is traditionally used on jubrakas and is one of the few

⁶The hungry period is primarily from July until the first far field harvests in October. First jubraka harvests generally occur in August.

instances where sedentary farmers have attempted to integrate their cropping and livestock production activities.

Based on the fact that the primary function of the jubraka is to provide households with food security early in the cropping season, it is recommended that on-farm trials should be initiated to evaluate improved varieties of early-maturing sorghum, cowpeas, and groundnuts. Further observations on the mixture of crops grown, cultural practices utilized, and labor inputs will also be made during the 1985/86 cropping season.

3. COMMODITY PRICE INFORMATION DATA BASE (CPIDB)

The purpose of this data base is to provide raw data on field and market prices for evaluation or monitoring of commodity oriented research activities undertaken by WSARP and other governmental or international organizations. Much of WSARP's Agronomy Section research activities involve the improved production of crops through the introduction of agricultural inputs or improved cultural practices. These innovations generally require an additional outlay of money capital for their adoption. These money costs, either fixed or variable, must be covered by resultant production increases or labor savings to be economically viable and therefore, acceptable to producers. Field and market commodity prices provide this information for site specific application to output from production activities.

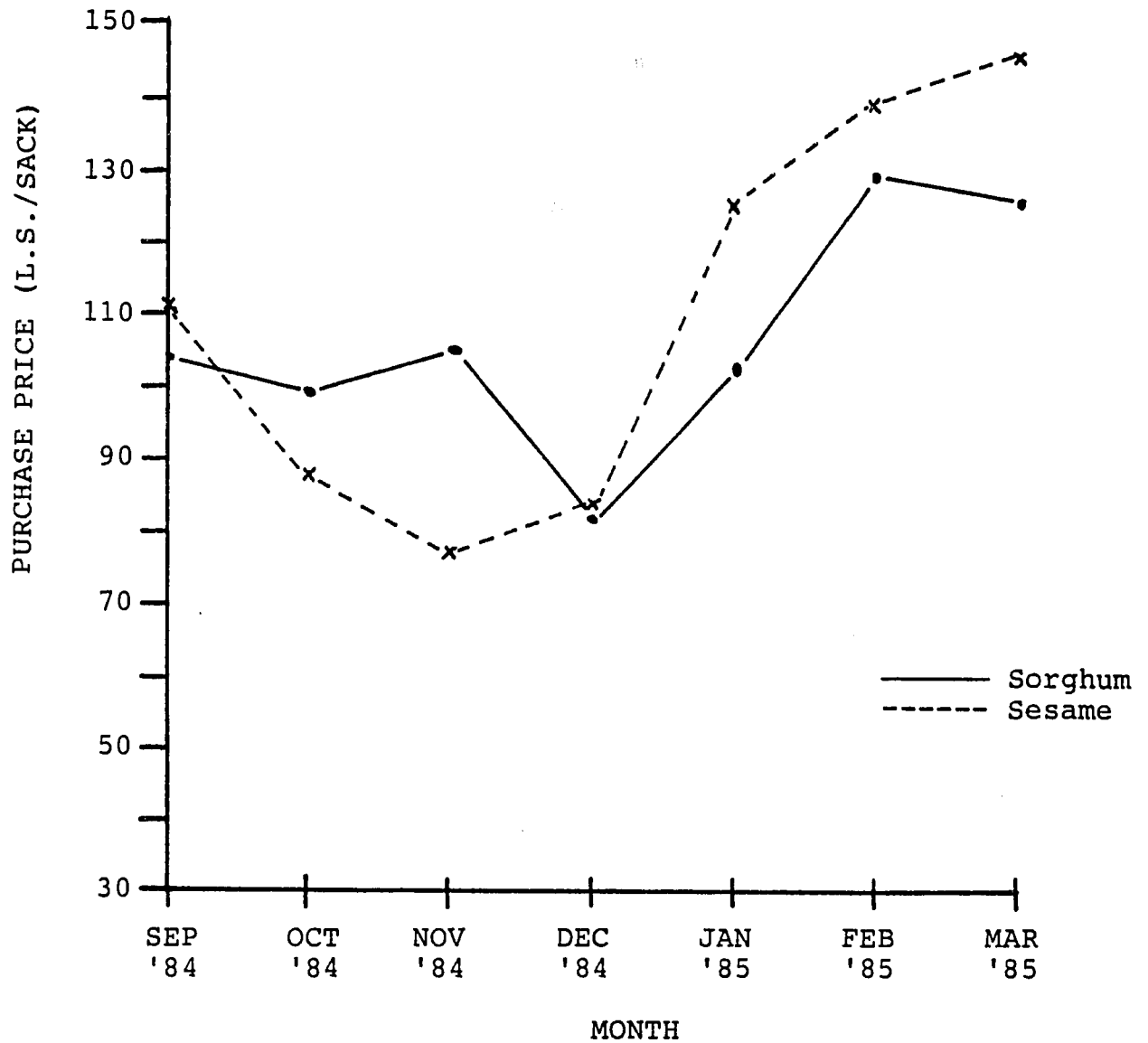
Fluctuations in commodity market prices have resulted mainly due to rainfall variations over the past few years. Very poor rainfall during the 1984/85 cropping season resulted in lower supply and increased prices. While food demand has been increasing due to the migration of people into the Kadugli area, the effective demand has been decreasing due to substantial increases in the price of food (see Figure 6). This has led to increased pressure on the farm household to rely on alternatives such as imported food grains and flour for their subsistence needs.

4. SUPPLEMENTATION OF THE 1983 SEDENTARY SURVEY

Thirty producers were enumerated on a one-time basis during the period from December 1984 through January 1985. Ten households were randomly

FIGURE 6

PURCHASE PRICE (L.S./SACK) OF SORGHUM AND SESAME IN THE
KADUGLI MARKET, SEPTEMBER, 1984 - MARCH, 1985



selected from the village of Dobeibat, representing the Arab, modern mechanized sector of traditional producers associated with the Nuba Mountain Agricultural Production Corporation (NMAPC), and ten households from each of the two village, Katcha and Kululu, which represented the traditional Nuba sedentary farming system. The purpose of the survey was to consider some aspects of the farming system which may have an important impact on the potential acceptability of recommendations made by WSARP scientists, specifically sociocultural and economic activities which affect producer behavior.

a. Sociocultural

Within many Nuba villages, the kujur, or religious leader, had a variety of functions, some of which directly impact on production, marketing, and household activities of the farming system. For example, he had a major role in determining the timing of celebrations (sibirs) which frequently signify the beginning of important production activities such as the planting or harvesting of sorghum. In some instances the kujur exercises considerable control over harvest dates for both far fields and jubrakas, and within the Nuba villages sampled, was a dominant factor determining the harvest dates of far farms. His influence was, somewhat less over jubraka harvest dates. By comparison, in Arab communities the dominant factor determining harvest dates from both production areas was crop maturity.

b. Production

The production of crops for food and sale occurs on two main areas, the far fields and the jubraka. Jubraka harvests occur before those on the far fields, and in general, both Nuba and Arab farmers harvested their last crop from the jubraka before December. Arab producers tended to harvest their jubraka crops earlier than their Nuba counterparts, with 66% harvesting their last jubraka crop in September compared to only 11% for Nuba farmers. More than 85% of Nuba farmers harvested their last jubraka crop in October and November compared to 32% for Arab farmers. Maize, which is an important jubraka crop, was not grown on far farms by any farmers. Though many reasons were given for not planting maize on the far farms, major problems appeared to be associated with pests and soil

fertility. If appropriate pest control measures can be identified, the introduction of such measures might encourage farmers to introduce maize on their far farms.

Producers were asked what types of inputs were needed to increase their production. Sorghum was considered very important because of its use in the production of marissa (local beer) which is a major input for the formation of a nafir (communal work party). Better tools for cultivation and early-maturing varieties were sought by farmers in the Nuba villages, as well as animals for the payment of nafir and hired labor costs. Dobeibat producers identified insecticides as an input which was very important. This response was a direct result of the NMAPC influence within the village and should be viewed as evidence that producers will use a new technological input if it is proven and available.

c. Marketing

Generally, commodities were marketed in the village near to where they were produced. The major crops sold to merchants in the sample villages were sesame, sorghum, okra, lubia, groundnuts, and cotton. Sesame and sorghum were the principal cash crops, as well as used to trade in the market for other goods. In addition, a number of commodities were collected from wild plants and trees, the most important being okra. In fact, the sale of okra was a major activity, generating large amounts of income in money or in kind, depending on the market where it was sold. Most marketing transport activities involved the use of pack animals. However, in Kululu, Nuba producers relied heavily on their women to carry out this activity. In Katcha, which is more remote than Kululu, producers relied on camels and donkeys. Dobeibat producers relied on mechanical means of transport such as lorries and bicycles, in addition to animal transport.

Livestock were produced for household consumption and sale by both Nuba and Arab farmers. In general, Nuba producers sold goats first while there was no clear priority for Arab producers with respect to the sale of small ruminants. Arab producers said they would sell cattle before either sheep or goats, possibly in an attempt to store stocks of grain as a hedge against anticipated high grain prices and low livestock prices. Additional

information is required to fully understand the strategies employed by producers with respect to livestock sales during periods of food scarcity.

d. Off Farm Labor

Off-farm labor provided income for many households in the three sample villages. It was estimated that during the 1984/85 "dead season" up to 40% of the adult male labor migrated to places other than their permanent home for wage labor. The majority of off-farm labor sought was either casual or field laborer positions. By far the largest remittance was as cash.

e. Household Consumption

Household food consumption was found to consist of a variety of products produced by the household, collected in the bush, or purchased in the market. The main dishes consumed in all villages were sorghum based and combined with other grains and/or gravies and relishes. Producers indicated that staple food supplies were generally available during the period from November through June but were of uncertain availability during the period from August through October. During this latter period households undertook a major effort to collect edible plants and tree fruits, mainly okra for home consumption or sale, and game animals, mainly rats, rabbits, and wild pigs.

SUMMARY OF THE TRANSHUMANT PRODUCTION SYSTEM

RESEARCH PROGRAM RESULTS

1984/1985

A. INTRODUCTION⁷

Research activities addressing migratory livestock production systems in South Kordofan have focused on the Messirya/Hawazma system, the predominate transhumant ethnic groups of the region. Livestock production in this system is characterized by seasonal migrations between dry season grazing areas in the southern and rainy season grazing areas in the northern parts of the region. The dominant livestock enterprise is cattle production, although substantial numbers of small ruminants, (sheep and goats), are also kept. There is a wide spectrum in cattle holdings, with some households owning in excess of several hundred animals, but the average number of cattle for the majority of households ranges from 50 to 100 head. The proportion of small ruminants to cattle is approximately 2:3. Herd demographics reflect a relatively high proportion of adult male animals, with the ratio of females to males, over 30 months of age, equal to approximately 3:1. Under traditional management practices cows are available for service throughout the year, and age at first calving is generally the result of first oestrus which occurs at approximately 3-4 years of age. Calving percentages and calving intervals range from about 55 to 60% and 20 to 22 months, respectively. Calf mortalities appear to be relatively low during the pre-weaning period, while calf growth and nutrition appear quite poor, with 14-20 month old animals rarely attaining a weight of 150 kgs. Overall herd losses resulting from culling (primarily infertility problems and bovine farcy) and deaths (primarily from malnutrition and outbreaks of rinderpest, pleuropneumonia, anthrax, and hemorrhagic septiciemia) range from 10-15% annually.

⁷A more complete description of the Messirya/Hawazma production system can be found in WSARP publication #22, "Research Program for the Kordofan Region, 1984/85."

Sheep, although of less importance economically and culturally than cattle within this transhumant system, play an important role in providing households with a source of ready cash for the purchase of subsistence market commodities. Sheep production has a relatively low priority amongst transhumant producers, being undertaken on a very opportunistic basis with little or no management input. Preliminary flock demographics indicate approximately 70% breeding females per flock, lambing intervals of about one year, and lambing percentages of about 75%. Lamb mortality appears quite high during the pre-weaning period with losses, primarily the result of respiratory infections, of up to 20% annually. Annual mortality among adult animals ranges from 15 to 20%.

Cropping activities play a secondary role in this production system. Sorghum, sesame, and cotton represent the major crops grown on the cracking clays, and millet and groundnuts on the lighter, sandier soils. It is estimated that migratory households produce approximately 1/5 to 1/6 of their yearly requirements for cereal grains, the remainder being purchased in local markets through the sale of livestock and livestock products.

Most transhumant households generate virtually all their income through the sale of livestock and livestock products. For Hawazma households it appears that milk sales alone may represent up to 35% to 40% of total subsistence income. Cash flow peaks during the rainy season when milk production is high and when the availability of local cheese factories in northern grazing areas facilitates the marketing of milk. Information collected to date suggests that subsistence income for most households is derived primarily from sales of milk, milk products, chickens, and small ruminants. Cattle sales are generally reserved for major purchases such as sorghum (estimated at approximately 30% of total household expenditures); additional and/or replacement livestock; the payment of school fees, and fines; and their purchase of clothing.

The primary constraint limiting improvements in livestock productivity for the traditional producers is their inability to manage or control the use of their natural resource base, resulting in intense competition for grazing and water. This competition severely restricts the time spent in the northern grazing areas, limiting animal productivity and the opportunity to market milk. In the South, grazing is limited by the unavailability of permanent sources of water and by widespread burning.

The end result is poor productivity, primarily due to inadequate year-round nutrition.

The objectives of the transhumant production system research program are: (1) to increase the efficiency of resource utilization in a way which is compatible with sustained, long-term improvements in the productivity of the natural resource base; and (2) to stabilize and improve livestock productivity and the sales of livestock and livestock products. The strategy adopted to achieve these objectives includes: first, an assessment of how producers are utilizing their available resources and what constraints are limiting animal productivity and marketing; and second, the testing of production increasing technologies which are potentially adaptable to and adoptable by traditional producers.

B. SUMMARY OF STUDIES ON THE SEASONAL NUTRITIONAL STATUS OF TRANSHUMANT LIVESTOCK

Contributing Scientists: Dr. B. Fadlalla, Animal Nutritionist; Dr. R.H. Cook; and Dr. I. Hashim, Range Scientist

1. INTRODUCTION

Diagnostic activities have focused on better defining the seasonal nutritional status of transhumant livestock under traditional management and husbandry conditions. The importance of these studies lies in being able to identify critical nutritional deficiencies which are having a negative impact on animal productivity. Once identified, efforts can then be made to overcome them through strategic supplementation during periods of critical nutrient requirements, i.e. during pregnancy, lactation, or breeding. Modifications in existing reproductive cycles can also be attempted so that the physiological needs of animals might be better matched to that available in the natural forage and browse. Another option might involve improvements in grazing management patterns. However, under existing land-tenure and land-use practices, this latter option would be difficult to implement because of the communal nature of rangeland exploitation.

2. STUDIES ON TRANSHUMANT CATTLE

Monitoring activities of the Kadugli Research Station's migratory and sedentary sentinel herds in 1984 (for background information see Bunderson et al., 1984⁸) have shown that:

- a. Animals lost most physical condition during the dry season and that up to 40% of their total annual loss in body weight occurred during the last 6-8 weeks of this period.
- b. Sedentary animals, maintained throughout the year on the cracking clays in southern Kordofan, had a level of productivity comparable with that of herds which undertook seasonal migrations. However, one to two years of adaptation to the

⁸Bunderson, W.T., Cook, R.H., and Fadlalla, B. 1984. Range/Livestock Research Activities, 1982/1983, WSARP publication #29, Khartoum, Sudan

climatic conditions in Southern Kordofan was necessary prior to achieving this level.

- c. Preliminary reproductive data indicated that migratory cows had calving percentages of 63.7 and 67.9% in 1983 and 1984, compared with 56.3 and 91.3%, respectively, for sedentary animals.
- d. The maintenance of cattle year-round in Southern Kordofan will likely require changes in traditional management, including the provision of adequate forage and water on a year-round basis, i.e. improved grazing management practices, and improved veterinary services and care, i.e. strategic control of ectoparasites and flies and vaccination programs.

Range nutrition studies which were initiated in 1984/85 have indicated some of the seasonal nutritional constraints of transhumant cattle in Southern Kordofan. These studies were undertaken with mature bullocks because of the ease with which these animals could be experimentally manipulated. However, the results are directly applicable to other classes of cattle when consideration is given to the nutrient requirements for specific types of production, i.e. weight gain, gestation, and lactation. Preliminary results from these studies have shown that:

- ♦ Fecal acid-detergent fiber increased steadily while fecal crude protein on organic matter basis (CPOMB) steadily decreased with advance of the dry season. Animals from both the migratory and sedentary herds lost weight suddenly in March, at a threshold of about 5% CPOMB. Migratory animals lost about twice as much weight in March compared to sedentary animals, although total weight loss during the dry season was similar for both herds.
- ♦ The energy density of grazing diets ranged from 1.38 ± 0.16 Mcal of metabolizable energy/kg dry matter in the dry season (1984) to 1.71 ± 0.05 Mcal of metabolizable energy/kg dry matter in the rainy season (1984). Animals were in a negative energy balance throughout the dry season and in positive energy balance during the rainy season.
- ♦ Crude protein intake ranged from 159.6 ± 58.8 grams/day in the dry season to 515.0 ± 102.6 grams/day in the rainy season. Animals were in a positive nitrogen balance during the rainy season (1984) to an extent which could theoretically support approximately 0.75 kgs gain/day.

- ♦ Phosphorus content of grazing rations ranged from 0.05% in the dry season (1985) to 0.13% during the rainy season (1984). Plasma phosphorus levels in adult female cattle indicated that approximately 60% were clinically deficient in this mineral during the mid-dry season (1985) compared to over 70% for just lactating animals during the same period. Over 95% of lactating cows appeared to be clinically deficient in phosphorus by the end of the dry season (1985) and during the rainy season (1984).

These results reflect the poor grazing conditions which existed during the 1984 rainy season and the 1985 dry season. Because of the poor rainfall in 1984, most transhumant producers were unable to migrate to their traditional northern ranges and were forced to utilize predominately cracking clay ranges in Southern Kordofan where the vegetation is generally of poorer quality. In addition, high livestock densities in many of the sampling areas limited the total quantity of forage on offer to grazing animals.

3. STUDIES ON TRANSHUMANT SHEEP

Range nutrition studies were also initiated in 1984/85 with several producer flocks. Preliminary results from these diagnostic studies have shown that:

- a. During the late rainy season (1984) pregnant ewes selected a diet consisting of approximately 90% forbs and shrubs and containing approximately 16.2% crude protein, resulting in a positive nitrogen balance.
- b. A low energy density of the grazing ration for pregnant ewes during the late rainy season (1984) resulted in energy being the most limiting nutrient requirement with the grazing ration supplying approximately 81.5% of the metabolizable energy requirements for maintenance and pregnancy.
- c. Plasma phosphorus levels in pregnant ewes during the late rainy season (1984) indicated that the majority of animals were deficient, with an average value of 4.15 ± 0.9 mg P/100 ml plasma being recorded.
- d. During the mid-dry season (1985), lactating ewes selected a diet containing approximately 8% crude protein and consisting of about 80% annual grasses. During this period the grazing ration supplied approximately 84% of the digestible protein requirements for both maintenance and lactation.
- e. A low voluntary intake of dry matter and low energy density of the grazing ration put lactating ewes into a negative energy

balance during the mid-dry season (1985). The grazing ration supplied only about 46% of the total metabolizable energy requirements for maintenance and lactation.

- f. Plasma phosphorus levels of lactating sheep during the mid-dry season (1985) indicated that all lactating ewes were clinically deficient, with an average value of 3.19 ± 0.6 mg P/100 ml plasma being recorded.

These results indicate a similar picture for transhumant sheep as was found for transhumant cattle. Under traditional management, sheep normally conceive during the early rainy season and lamb during the early dry season (November - January). Under normal rainfall conditions the availability of natural forage and browse would likely be higher than that found during the 1984 season, in addition to differences in forage quality between southern and northern ranges. As a result the negative energy balances recorded in this period may well have been greater than that found during a normal rainfall year. However, with peak nutritional demands occurring during the early dry season, energy and phosphorus may well represent two of the most important nutritional deficiencies, which may become even more limiting as the dry season progresses.

C. IN-HERD LIVESTOCK FEEDING TRIALS

Contributing Scientists: Dr. R.H. Cook, Livestock Production Specialist; Dr. B. Fadlalla, Animal Nutritionist

1. INTRODUCTION

Efforts to improve livestock output per unit of natural forage involve the implementation of research programs focused on identifying ways to improve the efficiency of natural forage utilization by livestock and/or to improve the quantity and quality of the natural forage on-offer to grazing animals. The first of these approaches generally seeks ways to improve animal husbandry and health while the second seeks to identify ways to improve the natural resource base through more conservationally sound grazing management practices which can be implemented within the context of existing land-use and land-tenure systems.

WSARP's research program to improve the productivity of traditional livestock has focused, to date, on the testing of potential interventions in the areas of animal nutrition and health. In addition, considerable thought had been given to methods for improving existing range management practices and discussions have been held with Regional policy-makers to examine ways to improve the deteriorating state of the natural resources of the region. However, until innovative, conservationally sound land-use policies are identified and implemented by policy-makers, WSARP views efforts to improve traditional grazing management practices as a rather unproductive effort.

2. CATTLE

The major research activity for 1984/85, which is addressing the problem of improving the dry season nutrition of transhumant cattle, involves an in-herd, researcher-managed, supplemental feeding trial (for details refer to Transhumant Production System Research Results 1984/85, volume #3: "Dry Season Supplementation of Baggara Cattle"). This trial, involving 100 breed-aged cows, is examining the production benefits from the feeding of sesame cake plus salt (experimental group) compared to those from the feeding of salt (producer practice) for a period of approximately

70 days during the latter stages of the dry season. This trial is still in progress, and the results reported here are preliminary and only reflect data accumulated through December, 1984. These results can be summarized as follows:

- a. Animals fed sesame cake plus salt gained weight during the supplemented period, +5.6 kgs/animal/period, while animals fed only salt lost weight, -9.1 kgs/animal/period. However, by the end of the 1984 rainy season there was no difference between treatment groups, the salt-fed group demonstrating a compensatory growth response.
- b. Animals supplemented with sesame cake plus salt produced significantly ($p < 0.001$) more milk than did animals fed only salt, i.e. 51.6 kgs/animal/period compared to 19.1 kgs/animal/period.
- c. Calves from dams supplemented with sesame cake plus salt had significantly ($p < 0.05$) higher birth weights, 18.6 kgs compared to 15.5 kgs, and significantly ($p < 0.05$) higher 30-day body weights, 31.3 kgs compared to 24.9 kgs, than calves from dams fed only salt.
- d. Packed cell volume (PCV) and plasma protein levels were normal for both treatment groups throughout the study period but were significantly ($p < 0.05$) higher by the end of the supplement period (June) in lactating animals fed sesame cake plus salt than in lactating animals fed only salt.
- e. During the supplement period plasma phosphorus levels were significantly ($p < 0.05$) higher, i.e. 5.5 mg P/100 ml plasma, in sesame cake/salt-fed animals, than in cows fed only salt, i.e. 3.4 mg P/100 ml plasma. However, the lowest plasma phosphorus levels were recorded in lactating animals from both treatment groups during the 1984 rainy season, i.e. 2.8 mg P/100 ml plasma. In lactating animals fed only salt, recorded plasma phosphorus levels indicated a clinical deficiency in over 90 percent of the animals for a period extending from the late dry season through the rainy season.
- f. Supplementation had no impact on either adult or calf mortalities, with one adult and one calf dying from each treatment group, all deaths unrelated to the supplementation. The most common diseases diagnosed were bovine farcy, with a 28% incidence in both treatment groups, and demodectic mange, with a 13% incidence in the sesame cake plus salt fed group and 21% incidence in the salt-fed group. Anaplasma marginale was the most common hemoparasite diagnosed, ranging in seasonal incidence from 2% to 10%, the highest occurring in the salt-fed group during the end of both the dry and rainy seasons.

- g. Economic analysis, considering only the benefits accrued from additional milk sales, showed a net marginal benefit/cost ratio of -0.18, when only lactating animals were supplemented, and -0.64, when all animals were supplemented, as was done in this trial.

The preliminary results of this trial indicated that the only production benefit to the producer during the first year of supplementation was an increase in milk production, which at best resulted in a net marginal cost of 18% at 1984 feed/milk prices (Figure 7). Assuming the same level of production in the 1985 trial, a net marginal cost is also expected because the price of sesame cake has increased 100% since January, 1984, while the price for milk and milk-products, outside of urban areas, such as Kadugli, has remained relatively stable.

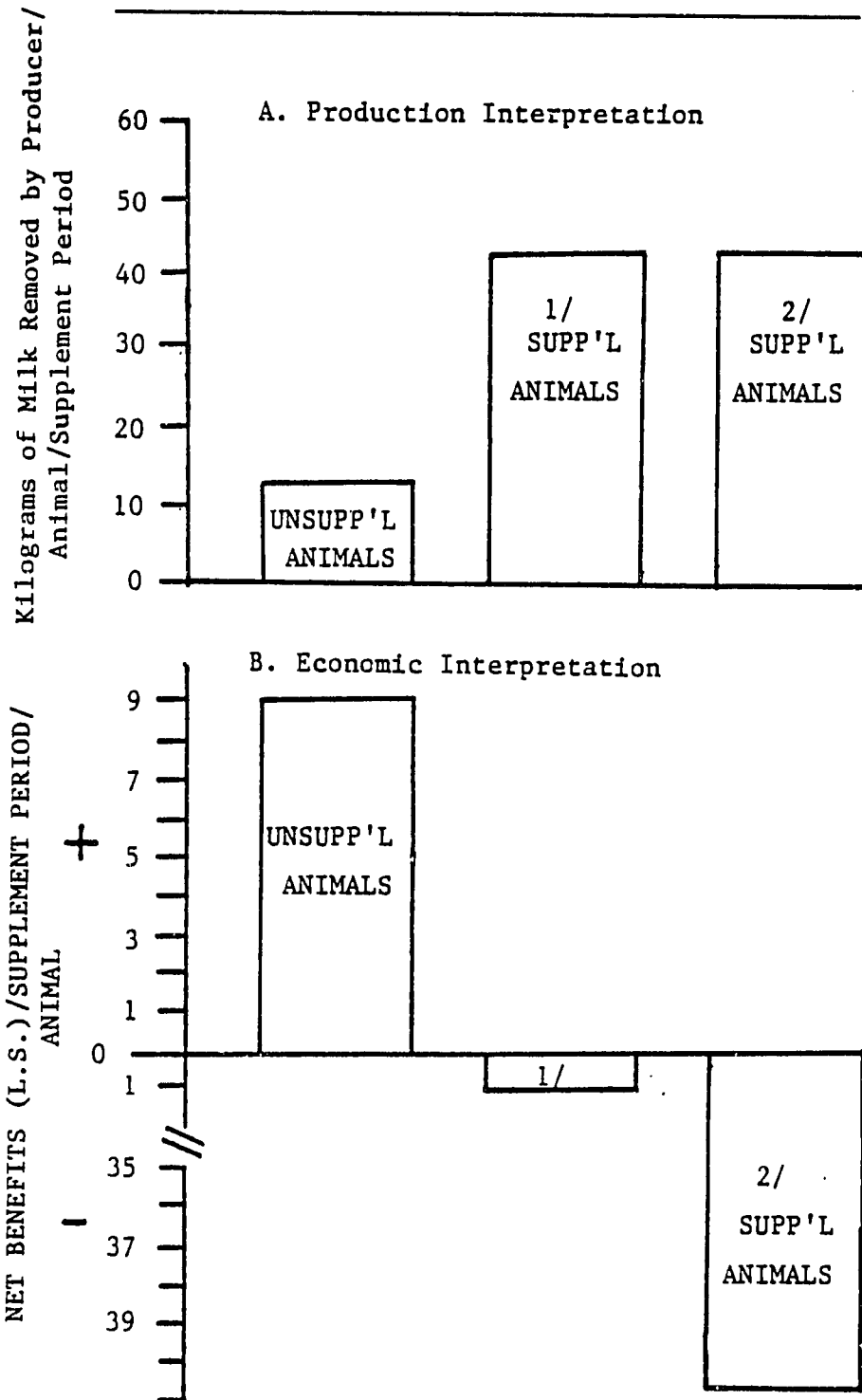
With improvements in the regional processing of sesame, in roads and transportation, and in markets for crops, crop by-products, and livestock products, the feeding of sesame cake may become economically attractive to more producers. Until that time, however, improved nutritional management practices for transhumants should focus on improving the utilization of the abundant, natural vegetation on many ranges in South Kordofan, minimizing the necessity for purchased feed inputs. In addition, efforts should be made to reduce production risks for producers while engendering a concept of natural resource management. An important step in this regard would be the implementation of a pilot study to investigate the establishment and operation of a dry season grazing reserve for specific groups of pastoralists on designated ranges in South Kordofan.

3. SHEEP

Initial diagnostic studies indicated that pregnant ewes were in a negative energy balance and had low plasma phosphorus levels during the late rainy season of 1984. Subsequent studies during the mid-dry season of 1985, when most ewes had lambed and were lactating, indicated that they were in both a negative energy and protein balance and that over 90% had plasma phosphorus levels that indicated a clinical deficiency. Because of the high nutritional demands of lactation, a supplemental feeding trial was initiated during the first of February, 1985. The details of this trial have been documented elsewhere (see Transhumant Production System Research

FIGURE 7

EFFECTS OF SESAME CAKE SUPPLEMENTATION
ON MILK PRODUCTION IN BAGGARA CATTLE '84



1/ Production and Net Benefits from supplementing at maintenance levels
for just lactating cattle in the treatment group

2/ Production and Net Benefits from supplementing at maintenance levels
all adult cattle in treatment group

Program Results, 1984/1985, Volume 3: "Dry Season Supplementation of Baggara Sheep".)

One hundred breeding-aged ewes from three producer flocks were divided into three groups and fed one of the following supplements; (1) salt only; (2) salt plus sesame cake; and (3) salt plus sesame cake plus a phosphorus supplement. All ingredients were fed to provide for a total calculated intake of salt, protein, and phosphorus equal to maintenance requirements, less that ingested through normal grazing. Initially it was proposed to supplement animals for 90 days but because of the poor grazing conditions in the trial area, a result of the drought and exceptionally high livestock densities, feeding was continued for a total of 103 days. Preliminary results showed that:

- a. Ewes in all treatment groups lost weight during the supplement period, with weight losses ranging from 16% for the salt plus sesame cake plus phosphorus-fed group to 22% for the salt-fed group.
- b. Average lamb birth weight were 3.22 ± 0.9 kgs for all treatment groups, and average daily gains were 132 gms and 108 gms for 30 and 90 days post-lambing, respectively. Average daily gains for all lambs during the supplement period ranged from 28 gms (from salt-fed dams) to 37 gms (from salt + sesame cake + phosphorus fed dams). There was no difference in lamb performance among any of the treatment groups.
- c. Plasma phosphorus levels for pregnant ewes in September 1984 (late rainy season) were, on average, 4.15 ± 0.9 mg P/100 ml plasma; however, by early February 1985 (mid-dry season) lactating ewes were clearly clinically deficient with a mean plasma phosphorus of 3.19 ± 0.6 mg P/100 ml of plasma (prior to supplementation). Forage phosphorus levels decreased from an average of 0.13% in September/October (1984) to 0.05% in February (1985).
- d. Packed cell volume (PCV) was normal for most ewes during the late rainy season (1984) with only 4% of sampled animals having values less than 25%. However, by the end of January (1985) 39% of sampled animals had PCVs less than 25%. No hemoparasites were diagnosed in any animals during the study period and fecal ova counts were consistently less than 45 ova/gm of feces.

- e. Plasma protein levels were generally normal during the late rainy season (1984) with 2% of the animals sampled having values less than 6 gms/dl. However, by the end of January (1985) 30% of the animals had values less than 6 gms/dl. Of those ewes with plasma protein values less than 6 gms/dl, 58% also had PCVs less than 25%, and of these 87% were lactating animals.
- f. Mortality of 90-day lambs averaged 16% of the total lamb crop (71 lambs), and most of the deaths were attributable to respiratory infections which occurred during the second and third months. There was no difference in lamb mortalities among ewe-treatment groups. Preliminary ewe mortality data suggested that more animals die from the salt-fed group than from the other two groups, however, some of this difference appeared to be the result of differences in flock management among producers.

Final assessment of the impact of supplementation will not be completed until the 1985 lambing season. However, from the preliminary data present here, it appeared that the level of supplementation fed in this trial was inadequate to produce significant increases in ewe productivity. Part of the reason for the general poor performance of animals in this trial was the exceptionally poor rains in 1984 which resulted in an abnormally stressful dry season for all transhumant livestock. In years with average rainfall, improvements in sheep productivity are considered possible, but even under favorable climatic and economic conditions it appears unlikely that the supplemental feeding of sesame cake to Baggara sheep will ever show a high enough economic return to encourage producers to adopt the practice. This is particularly true even in average rainfall years, when sesame cake is in short supply in the Nuba Mountain area because of the high demand for its use to supplement milking cattle which are maintained near the Kadugli urban market and because of the limited number of sesame presses.

Alternative supplemental feeds do exist, however, and cowpea forage appears to be one legume suitable for supplying both crude protein, energy, and phosphorus to either productive ewes or weaned lambs. Future trials with Baggara sheep should explore the production benefits from: (1) early weaning lambs and supplementing the last two months of the dry season with a ration consisting primarily of cowpea forage; and (2) supplementing pregnant and lactating ewes with a phosphorus/salt supplement. The Kadugli Research Station's agronomy and range program is emphasizing the expansion of food and forage legumes within the sedentary cropping system. The

success of these activities could well provide sedentary producers with the option of purchasing lambs during the dry season, when prices are low, for supplemental feeding or selling forage to transhumants.

D. FLOCK DEMOGRAPHICS AND PRODUCTIVITY OF SHEEP

Contributing Scientist: Dr. W.T. Bunderson, Range-Livestock Ecologist

1. INTRODUCTION

The importance of sheep to Western Sudan is apparent from the animals' contribution to foreign exchange earnings, and the role it plays in the various marketing and consumption activities of traditional livestock systems. Although Sudan recognizes the value of sheep to national and household economies, attention has rarely focused on these animals, and few attempts have been made to determine the production parameters and potential of indigenous sheep.

The overall goal of sheep research by the Kadugli Station is to increase the stability and commercialization of sheep production under traditional management. Immediate objectives of this study were:

- a. to establish the level of productivity and size of sheep flocks among the transhumant Baggara in South Kordofan, and
- b. to determine if a potential exists for substantial improvements in production.

2. SAMPLE METHODS

During the mid-dry season months of January and February 1982, ten flocks of sheep were examined to determine their general size, composition, and productivity on a household basis. The groups involved were randomly selected from four different sites in the Nuba Mountains within a 50 km radius of Kadugli. An additional five flocks were examined during the wet season from mid August to mid September following the annual migration of the Baggara to the north. A total of 934 sheep were sampled in the dry season, and 358 sheep in the wet season.

For each animal, information was recorded on sex, physiological status, and age according to five general classes, 0-2 months, 3-6 months, 7-12 months, 13-24 months, and 2 years and over. Lambs were regarded as animals 6 months old and under, with breeding-age beginning at 10 months (see Wilson, 1976).

3. FLOCK STRUCTURE AND PRODUCTIVITY

Detailed results are provided by Bunderson (1985) in Vol II of the 84/85 Annual Report. Important structure and production characteristics of the combined flocks are presented on an annual basis in Table 7.

Mean flock size across seasons was 89. Total females made up 75-80% of the flocks, with breeding females accounting for 55-60% of the animals. The percentage of breeding females ranged from 74-90% when lambs were subtracted from the flocks. No castrates were recorded in either sample period, and breeding-age males were low in numbers, particularly over two years of age.

The proportion of female to male lambs was close to parity at a ratio of 1.1:1. This apparent though small differential could be attributed to greater mortality of male lambs because of better management for females and their dams. It could also reflect some off-take of males for consumption or market sales. Although a definite lambing peak occurred from December to February, there were lambs born at most times of the year. This means that sheep which missed conception during the rainy season, and those just reaching maturity, can be bred successfully at other times of the year, provided nutrition is sufficient for oestrus to occur. The peak period for lambing, however, was clearly a result of oestrus and conception beginning soon after the break of the rains when forage conditions dramatically improve.

With a gestation of five months, sheep are potentially capable of breeding twice/year, but this rarely occurs among Baggara sheep due to the harsh environment and limiting nutrition. The proportion of lambs 6 months and under to breeding ewes (10 months and over) averaged 63% for the dry-season sample, compared with 34% for the wet season. This includes an average twinning percentage of about 10%. Assuming that the lamb composition at the time of sampling reflects a mortality of 15% (see Wilson, 1976 for South Darfur), the percentage of lambs born would be 74% and 40% for the dry and wet season samples respectively. Adjusting for a one month overlap of lambs between the two sample periods (see Table 7), an annual lambing rate of 106% is derived.

An overall production index is calculated on an annual basis by combining the productivity values for each season with adjustment for the one month overlap of lambs. The production formula is given below:

$$(\% \text{ Lambs/Breed.Ewes}) \times (\text{Lamb Survival}) \times (\% \text{ Breed.Ewes/Flock-Lambs})$$

TABLE 7: ANNUAL PRODUCTION CHARACTERISTICS
OF BAGGARA SHEEP

PRODUCTION PARAMETERS

Parturition Interval	11-13 months
Age at First Parturition	15-18 months
Breeding Age	10 months
Lambs Born/Breeding Ewes*	106.0%
Twinning in Lambing Ewes	10.2%
Breeding Ewes/Flock	57.2%
Breeding Ewes/Flock-Lambs	83.1%
Total Females/Flock	79.3%
Total Males/Flock	20.7%
Lamb F:M Ratio	1.1:1
Breed, F:M Ratio	14.8:1
Peak Lambing Season	Dec-Feb
Peak Breeding Season	Jul-Sept
Post Natal Mortality (0-1 month)	15.0%
Pre-Weaning Mortality (1-6 months)	10.0%
Adult Mortality	15.0%
Production Index/Annum	0.69

* Calculated as follows:

(% Dry Season Lambs/Breed, Ewes) +

(% Wet Season Lambs 1 month/Breed, Ewes) x 1.153

Lambs 1 month were subtracted from the % wet season lambs/breed, ewes to avoid possible double counting since these lambs could overlap with the 6 month old lambs in the dry season sample. The result is added to the % dry season lambs, and multiplied by 1.15 to represent the actual number of lambs born, (i.e., the composition of lambs in the flocks are assumed to reflect an 85% survival rate).

Based on Wilson (1976) and Cook (personal communications), lamb survival from birth to 6 months was estimated at 75%. However, since the flock composition already reflects an estimated lamb mortality of 15% (see above), a 10% mortality was applied to the remaining lambs for the formula above. The result produces an annual production index of 0.69. This is more than double the productivity of Baggara cattle under the same environmental conditions (see Bunderson et al., 1984), but is still relatively low compared with extensive sheep operations in developed countries.

Offtake for consumption and market are high in Baggara flocks, particularly with regard to male animals, although considerable numbers of females are also removed, usually older or sick animals and those which have not yet lambed. The low proportion of breeding males (particularly pronounced during the dry season when breeding demands are low), indicates that producers keep only a sufficient number to ensure servicing of ewes. For a highly orthodox Muslim society such as the Baggara, a balance must be met between heavy demands for offtake, and the maintenance of flock size and productivity.

4. IMPLICATIONS FOR MANAGEMENT

As pointed out by Cook and Fadlalla (1985), sheep production by Baggara is opportunistic with good husbandry practices neglected in favor of cattle. From the results presented here, there appear to be two over-riding limitations on the potential productivity of Baggara sheep. The first is the high mortality of lambs, and the second is the seasonality of lambing. In many ways, these two factors are interactive. The basic problem is that many lambs are dropped during the dry season when forage and environmental conditions are most limiting. There is also a high incidence of pneumonia during this season, leading to mortality of both lambs and adults (Cook and Fadlalla op. cit.). Stress is particularly acute for pregnant and lactating ewes, and hence for suckling lambs. The results reduce the resistance of these animals to common diseases, with a compounding effect on nutritional deficiencies, usually manifested in high mortalities.

Improved veterinary services offer potential for combating disease and parasitic infections to increase survivability, but the nature of these services, along with their associated costs and logistics are currently unknown. A second alternative involved feeding a cheap, high quality supplement during the dry season to pregnant and lactating females (and possibly lambs) as suggested by Cook and Fadlalla, op. cit. The most likely supplement to use appears to be a legume forage, the production of which is discussed by Bunderson (see Legume Integration, this volume). Ideally, it would be desirable to manipulate the breeding season so that most lambing occurs during the rainy season when nutrition is at its peak, rather than during the dry season. To do this, breeding must be controlled in the rainy season, and a supplement must be fed to ewes in the late dry season to induce oestrus. The results of this plan would improve lamb growth and development, and significantly reduce mortality, disease, and nutritional stress for all classes of sheep. The danger of this plan is that there will be a tendency for the main lambing season to revert back to the mid-dry season. This is because the replacement ewes in the flock will not have reached breeding age by March or April, but will be ready by June or July. Producers will not wait until the following March for the first breeding of these ewes at 18 months of age. This cyclic problem will continue until we are back to the present situation after 4-5 years.

5. CONCLUSIONS

The current productivity of Baggara sheep is reasonable under existing conditions, but with modest interventions, substantial improvements are feasible. Relative to other species raised by Baggara, sheep production is far more commercially oriented, such that improvements will likely be directed toward increased market off-take. Given the deteriorating resource base in Western Sudan, and prevailing attitudes for investing in cattle, which only exacerbates the situation, improvements in sheep production offer an attractive proposition to increase both production and off-take, while encouraging a greater market orientation toward livestock in general.

E. LIVESTOCK PRICE INFORMATION DATA BASE (LPIDB)

Contributing Scientist: Dr. T.E. Gillard-Byers, Agricultural Economist

1. INTRODUCTION

During 1983 the Socioeconomic section initiated the collection of livestock price information in the Kadugli livestock market. This activity had been continued, relying on tax records as a source of daily livestock prices and volumes. Three species of livestock have been considered, i.e. cattle, sheep, and goats, and prices and volumes of sales have been broken down by sex (see Figures 8, 9, 10).

2. CATTLE

During August 1983, the average monthly price for male cattle was £S 319.71/head and the mean price for females was £S 297.50/head. By August 1984 the sale price for male cattle had slipped to £S 243.34/head and £S 176.78/head for females. By January of 1985 the prices had continued their downward trend to £S 140.15/head and £S 119.28/head for males and females, respectively.

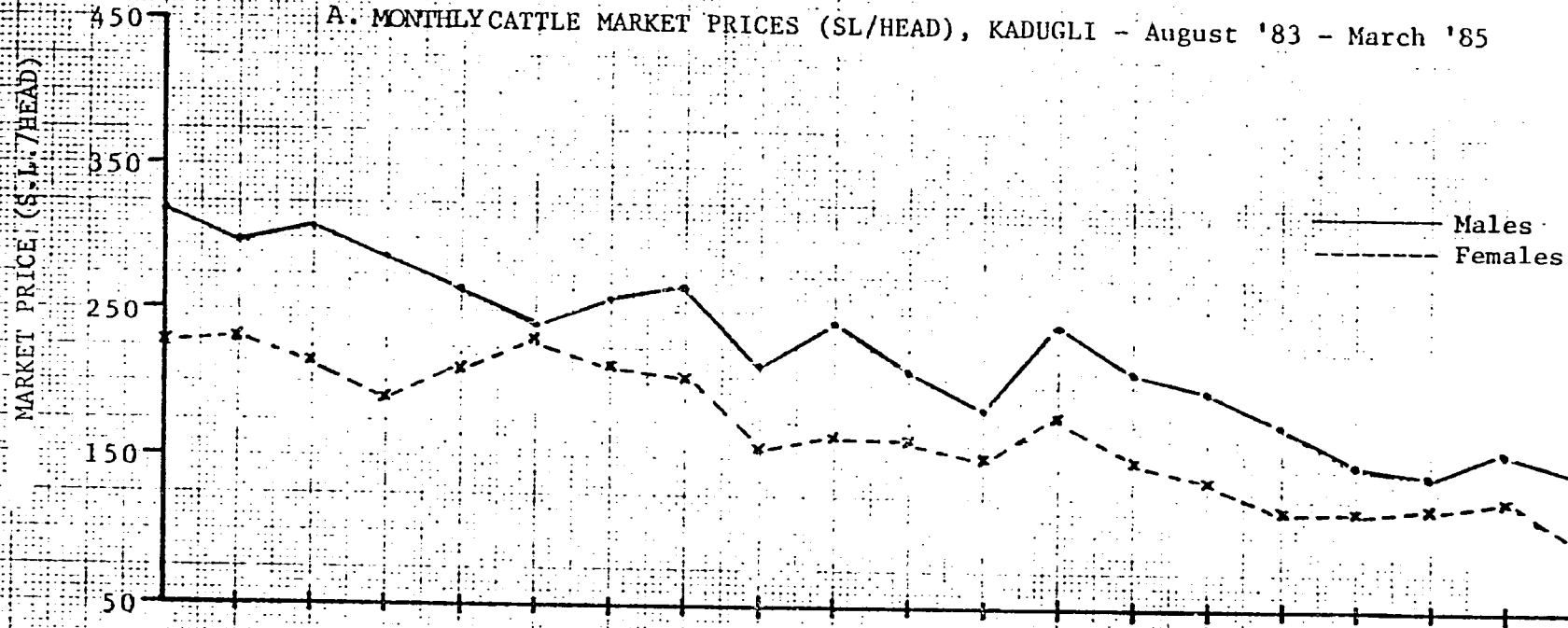
3. SHEEP

Price trends for sheep, both male and female, showed similar downward in nominal terms over the period. Male sheep sold for £S 42.29/head in November/December, 1983, compared to £S 30.95/ head for the same period a year later. The volume of sales recorded for male sheep fluctuated a great deal where, for example, twenty-eight rams were sold during November/December, 1983, two hundred and seventy-five were sold during the same period in 1984. This was a direct result of increased staple food expenses and corresponding increases in the demand for cash to purchase daily food requirements. Corresponding increases in the sale of ewes did not occur until January, 1985, reflecting the desire of producers to dispose of male animals before disposing of breeding stock. As was the

FIGURE 8

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A. MONTHLY CATTLE MARKET PRICES (SL/HEAD), KADUGLI - August '83 - March '85



B. VOLUME OF CATTLE SALES (#-HEAD/MONTH), KADUGLI MARKET-Aug. '83 - Mar '85

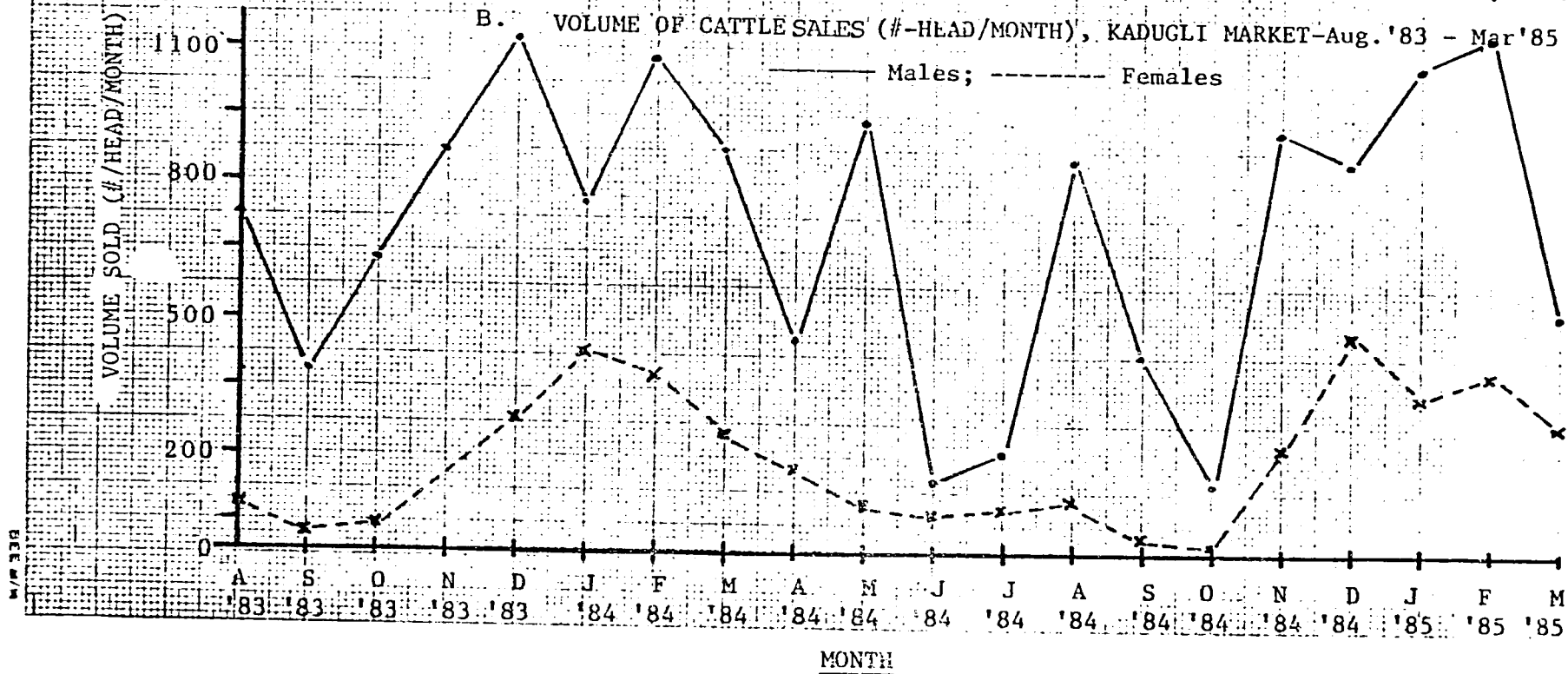


FIGURE 9

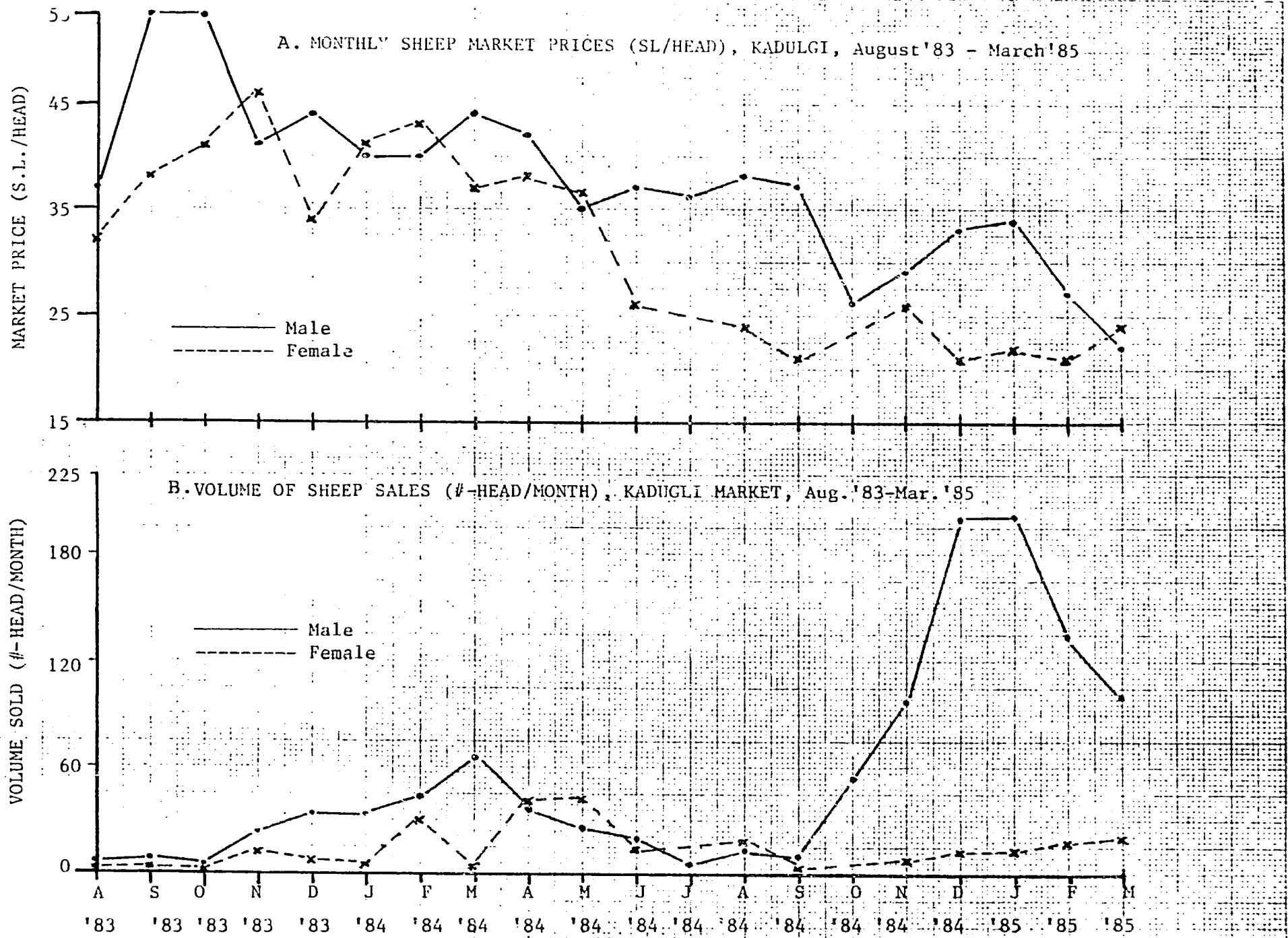
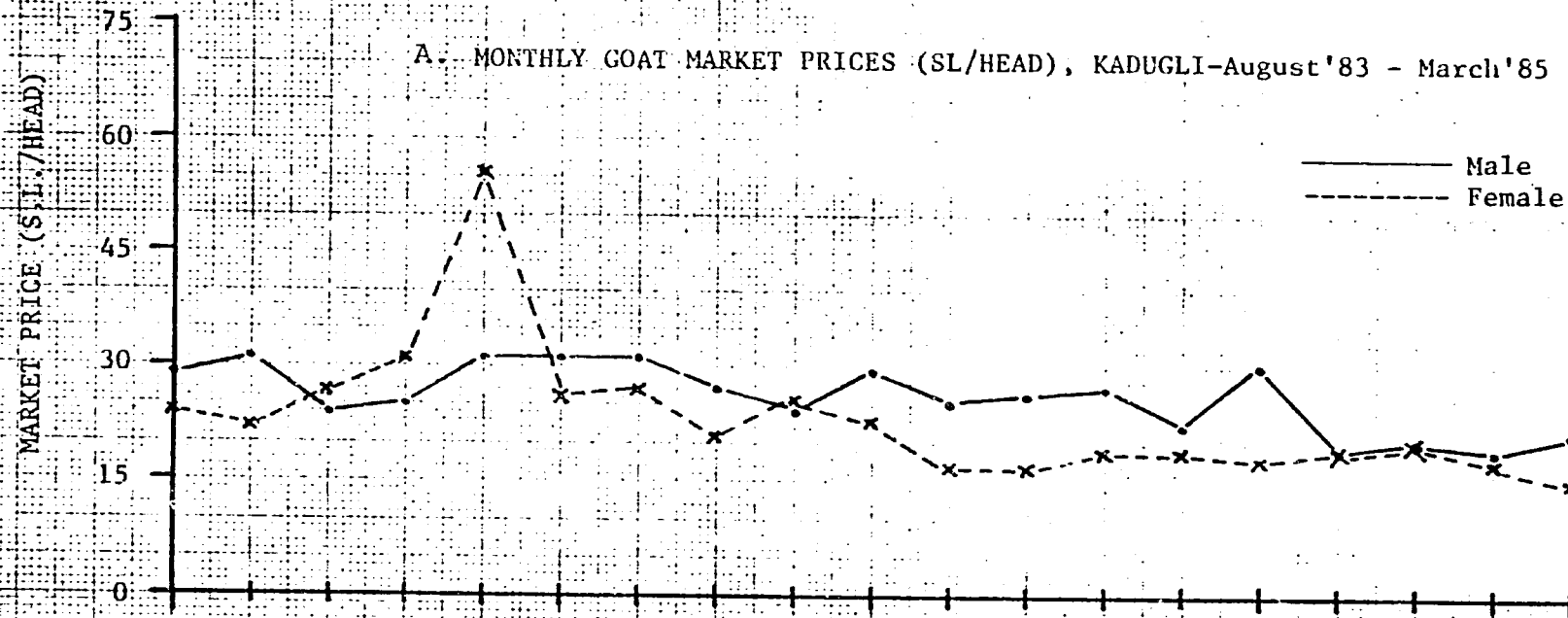


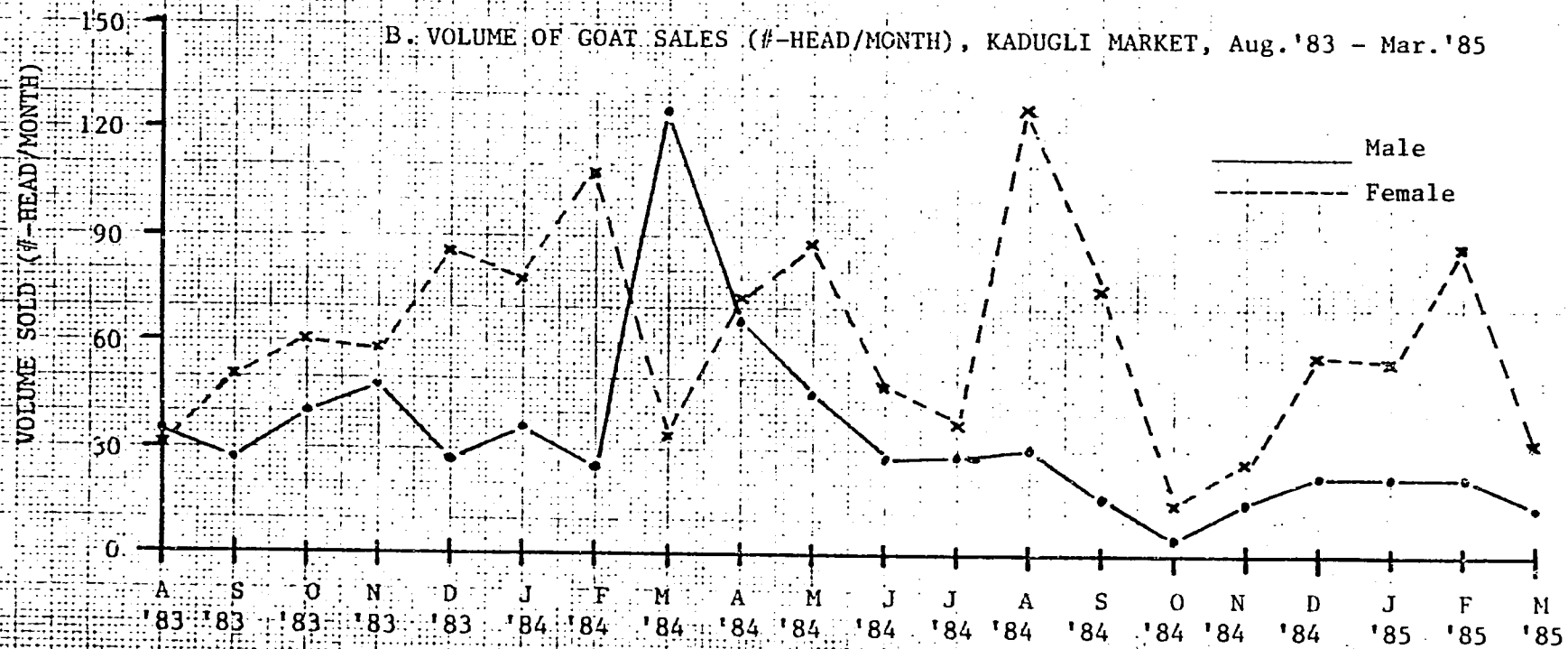
FIGURE 10

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A. MONTHLY GOAT MARKET PRICES (SL./HEAD), KADUGLI-August '83 - March '85



B. VOLUME OF GOAT SALES (#-HEAD/MONTH), KADUGLI MARKET, Aug. '83 - Mar. '85



MONTH

case for males, the price for ewes decreased from £S 39.93/head in November/December, 1983, to £S 23.62/head during the same period a year later.

4. GOATS

Although the sale price for male goats also showed a downward trend from 1983, the volume of sales decreased through December/ February, 1985. This decrease may partially be the result of the goat's greater survivability during times of drought, when compared to cattle and sheep, which allowed producers to reduce sales early in the dry season and maintain an economic base which could be used at a later date.

5. PRODUCER MARKETING STRATEGY

The marketing strategy of producers is quite complex and is not monopolized by an interest in cattle. Variables which appeared to affect the decision of what species and sex of animal to sell included rainfall patterns, commodity prices, demand for liquidity, and the type of scale of anticipated purchases.

Small purchases are nominally made through the sale of small ruminants. However, during the 1984/85 period, the market price of sorghum (the staple food) made this strategy impossible to follow. The sale price/sack of sorghum in December 1984 was approximately £S 83.0, and by May, 1985 the price had risen to £S 138.0/sack. The price ratio of male cattle to sorghum/sack was essentially 1:1.

The collection of livestock market information will continue during the 1985 cropping season, and information from marketing research studies will be used to supplement this data base.

F. TRANSHUMANT PRODUCTION SYSTEM DYNAMICS -THE INAINAT MESSIRYA

Contributing Scientist: Mr. M. Abu Sabah, Sociologist

1. INTRODUCTION

The Range/Livestock Section is investigating the potential impact of a protein/phosphorus supplement on the dry season performance of transhumant cattle in South Kordofan Province. This two-year feeding trial, utilizing sesame cake and salt, is attempting to quantify the production benefits from feeding such a supplement in terms of increased milk production, improved reproductive performance, and improved calf growth and viability. The present study was undertaken to provide additional information on the production practices and decision-making among the producers cooperating in this trial.

2. PRODUCTION CHARACTERISTICS

The Inainat are a sub-tribe of the Messirya Baggara, a transhumant group with a long history of cattle production. Within this culture the general trend has been the accumulation of wealth through accumulating cattle, and with them, prestige and political and social influence. The primary production characteristics of this target group are; (1) emphasis on livestock production, particularly cattle; (2) limited cropping activities, occasionally in association with a mechanized scheme; and (3) seasonal migrations from their dar (home area) in South Kordofan to rainy season grazing areas in North Kordofan.

There is a great variation in the number of cattle owned by individual households in this transhumant group, with herds ranging from just a few animals to over 200 head. Approximately 25% of the households have from 2 to 15 head while from 5% to 10% of the households appear to own more than 100 head. The majority of households own between 20 and 100 animals, and approximately 25% own no cattle. In this latter group, adult males generally seek off-farm employment, either in mechanized schemes, urban areas, or in the Gulf states, or concentrate their production activities on the cultivation of crops.

Two types of cropping systems are common. One involves the Nuba Mountain Agricultural Production Corporation. Under this system producers are provided with approximately 8 feddans, half of which must be planted to cotton and the remainder to traditional grain crops, usually sorghum and sesame. The second involves the more traditional bush-fallow system of cultivation where sorghum and sesame are the principal crops grown.

Livestock production, particularly the raising of cattle, is considered by producers to be the most profitable production enterprise. These producers have developed their own breeding practices where bulls are generally selected from within herds based on the productive performance of the bull's dam, as well as on its own physical characteristics such as conformation and color, red is preferred. The selection process is not an individual decision, but rather a long process in which members of the fariq are involved. Each herd has its own herd bull, no attempt is made to restrict servicing between particular bulls and cows. Producers also consider that the productive potential of heifers is related to the productive performance of their dams.

Milk production is an important component of herd productivity for this transhumant group. In addition to its recognized contribution to the growth and performance of calves, milk plays an important part in household nutrition. Milk sales also make a substantial contribution to household income. Although traditional cattle are generally low milk producers, producers attempt to increase milk production by increasing the number of lactating animals in their herds.

Transhumants practice various forms of feed supplementation for their animals generally for cows in late pregnancy, injured and/or weak animals that cannot graze, recently calved cows, and orphaned calves. Commonly used supplements include; cotton seed cake, sorghum grain and stalks, groundnut tops, salt, and Balanites leaves, which are often provided to livestock during the dry season.

Several factors are important in relation to the supplemental feeding of livestock for producers, such as cost and availability. Feed transport problems and the labor requirements for implementing a supplemental feeding program are also considerations. Only economically-abled producers can afford to buy concentrates, and the amounts of cotton seed cake and sesame cake which are traditionally fed are low and erratic. The main aim of

feeding concentrates is either to improve milk production, or to help animals regain their physical condition so that they can better utilize the available grazing. In order to encourage a more scientifically sound use of supplemental feeds, supplements should be locally available and simple in composition; require relatively low quantities to be fed; be inexpensive and not require large resource reallocation within households.

SUMMARY OF RANGELAND EVALUATION AND LAND-USE IN SOUTH KORDOFAN

Contributing Scientist: Dr. W.T. Bunderson, Range-Livestock Ecologist

A. INTRODUCTION

Range management as a science is relatively new and undeveloped in Sudan, and as a tool for improving the long-term productivity of livestock among pastoral groups, it is virtually nonexistent. With the growing demands for increased crop and animal production, the need for range management and improved animal husbandry is more acute than ever. This is particularly true of areas with serious land-use conflicts, and where over-exploitation has led to declining crop and livestock productivity.

The rangelands of Western Sudan and the livestock they support represent one of the region's principal resources, and as such, contribute significantly to the economic and agricultural productivity of the country as a whole. In terms of food for ruminant animals, natural and improved pastures remain the world's most important crop. It is therefore vital that the rangelands in Western Sudan be maintained and managed with the same degree of care and planning applied to other crops. The detrimental impacts of increased land-use pressures during recent decades in Sudan are precipitating an urgent need for changes in traditional grazing and cultivation practices, if long-term improvements in crop and livestock productivity are to be realized.

Research into range resources in the Nuba Mountain region was designed to address the current utilization and productivity of rangelands in relation to their potential. The type and nature of research activities conducted are summarized below.

B. CLASSIFICATION OF RANGELAND COMMUNITIES

Major rangeland communities in the Central Districts of South Kordofan have been classified on the basis of botanical composition, physiognomy, topo-edaphic characteristics, and climate. A preliminary classification is provided in Bunderson (1981), and a detailed description is being published as a separate report. In general, vegetation communities are heterogeneous

and complex, but strongly associated with land-form and soil type. On this basis, vegetation can be distinguished into the following broad categories:

1. Deciduous broad-leaf savanna on sandy clay and loam soils of jebel hillsides and footslopes;
2. Semi-deciduous thorn savanna on cracking clay plains;
3. Mixed thorn and broad-leaf savanna on non-cracking clay plains;
4. Swamp grassland on seasonally flooded cracking clay depressions;
5. Mixed thorn and broad-leaf savanna on alluvial plains; and
6. Riparian semi-evergreen woodland along drainage courses.

Within each of these zones are found several plant communities, all exhibiting some degree of variability due to local changes in soils and relief as well as the effects of human activities and grazing by livestock.

C. THE ECOLOGICAL STATUS AND LAND-USE POTENTIAL OF SOUTH KORDOFAN RANGELANDS

The most important uses of range resources in South Kordofan are (1) pasture and browse for domestic livestock, and (2) sources of fuel and building material for the rural and urban populations. Assessments of the current condition and productivity of rangelands in the region have been discussed in earlier papers based on data collected from 1981-1983 (Bunderson, 1984; Bunderson et al., 1984). Results for the wet and dry seasons of 84/85 support the contentions made concerning the influence on rangeland of grazing, fire, cultivation, and tree cutting, but also demonstrate the significant effects of drought. Details of these and other factors affecting range resources are discussed in Volume IV of the 1984/85 annual report, which also includes a breakdown of the current and potential land-use of the province according to eco-climatic zones.

In order to achieve significant advances in traditional rainfed agriculture, a concerted effort must be made among governmental entities, donor agencies, and scientists to develop policies for implementing effective land-use plans with full collaboration from the agricultural groups involved. Given the nature of land-tenure in Western Sudan, it is fatuous to expect progress from grazing and range improvement programs.

The success of such programs depends almost exclusively on the control and manipulation of a variety of factors. Some of the more obvious include:

1. the timing, distribution, and intensity of grazing in terms of the location, ownership, number, and relative proportions of animals by species (i.e., whose animals are allowed to graze where, when, for how long, and at what density);
2. the extent, season, and frequency of fires;
3. the use and disposition of fallow land;
4. the encroachment of cultivation, both traditional and mechanized;
5. the management costs and inputs associated with improvements in native rangelands (pastures and woodlands); and
6. the cutting or harvesting of trees for fuel, construction, and land preparation.

Under the communal pattern of land-use currently prevalent in the region, pastoralists simply lack the necessary control over the resource base to improve range conditions and grazing practices. This is largely related to recent changes and increased land pressures brought about with the advent of the European in the 19th Century. The former dominance of specific regions or territories by individual groups for a single type of land-use is giving way to multiple land-use pressures from competing groups. The results have dramatically altered the context under which traditional systems once functioned. These conditions have reduced any real or desired influence over land-use practices, leading to opportunistic forms of exploitation in place of rational use. The results of expanding fallow and shifting cultivation, mechanization, charcoal making, widespread burning, and overgrazing have contributed to an accelerated deterioration of the resource base. Problems of declining agricultural productivity and land degradation must therefore be addressed within an operational framework constrained by the "tragedy of the commons".

D. LAND-USE PLANNING FOR AGRICULTURAL DEVELOPMENT

1. INTRODUCTION

In order to realize the high agricultural potential of Western Sudan, sound land-use policies must be formulated for effective implementation.

Such policies are fundamental to the success of range-livestock development efforts, which for long-term improvement, should address the causes of production constraints rather than their symptoms. Examples requiring this approach include:

- a. reseeding rangelands to improve their productivity and quality for grazing and soil stabilization, either through aerial application or normal ground procedures;
- b. reforestation for soil stabilization, replenishment of wood and wood products, nutrient recycling, and browse/fodder production;
- c. the control and/or use of fire;
- d. water development, particularly in the more fragile rangelands of the north, to improve the availability of grazing and distribution of livestock; and
- e. introduction of grazing management systems, and/or changes in the seasonal distribution of livestock to improve range and livestock productivity.

Depending on location, many of these efforts may be prohibitive due to cost. In areas of low agricultural potential, or where deterioration has been especially acute, the technical and sociological difficulties of reclaiming them may simply be intractable. The point made here is supported by the unimpressive record of development in semi-arid Africa, but illustrates the inappropriate identification and application of potential improvements, rather than an absence of relevant technical information.

WSARP recognizes the enormity of the land-use question in Western Sudan. While the project has not been directly involved in this issue, land-use policy and planning are ostensibly keys to reconciling many of the problems of agricultural production in the country. Investigations into the ecological status and utilization of rangelands in South Kordofan have provided a basis for an initial attempt to address land-use planning as applied specifically to pastoral-dominated systems. the design of such a plan for South Kordofan is outlined on a strictly experimental basis below.

2. AN INTEGRATED LAND-USE PLAN FOR THE TRANSHUMANT AGRO-PASTORALISTS IN SOUTH KORDOFAN

a. Introduction

Livestock in Kordofan represent a major agricultural and economic resource for Sudan. Worldwide in this climatic zone, productive agricultural systems invariably integrate the livestock component. However, changing land-use pressures and conflicting agricultural interests are undermining traditional forms of livestock production. This is largely related to the limited influence of livestock producers over patterns of resource use. With production almost entirely under traditional management, land-use planning is requisite to the long-term stability and improved productivity of these systems.

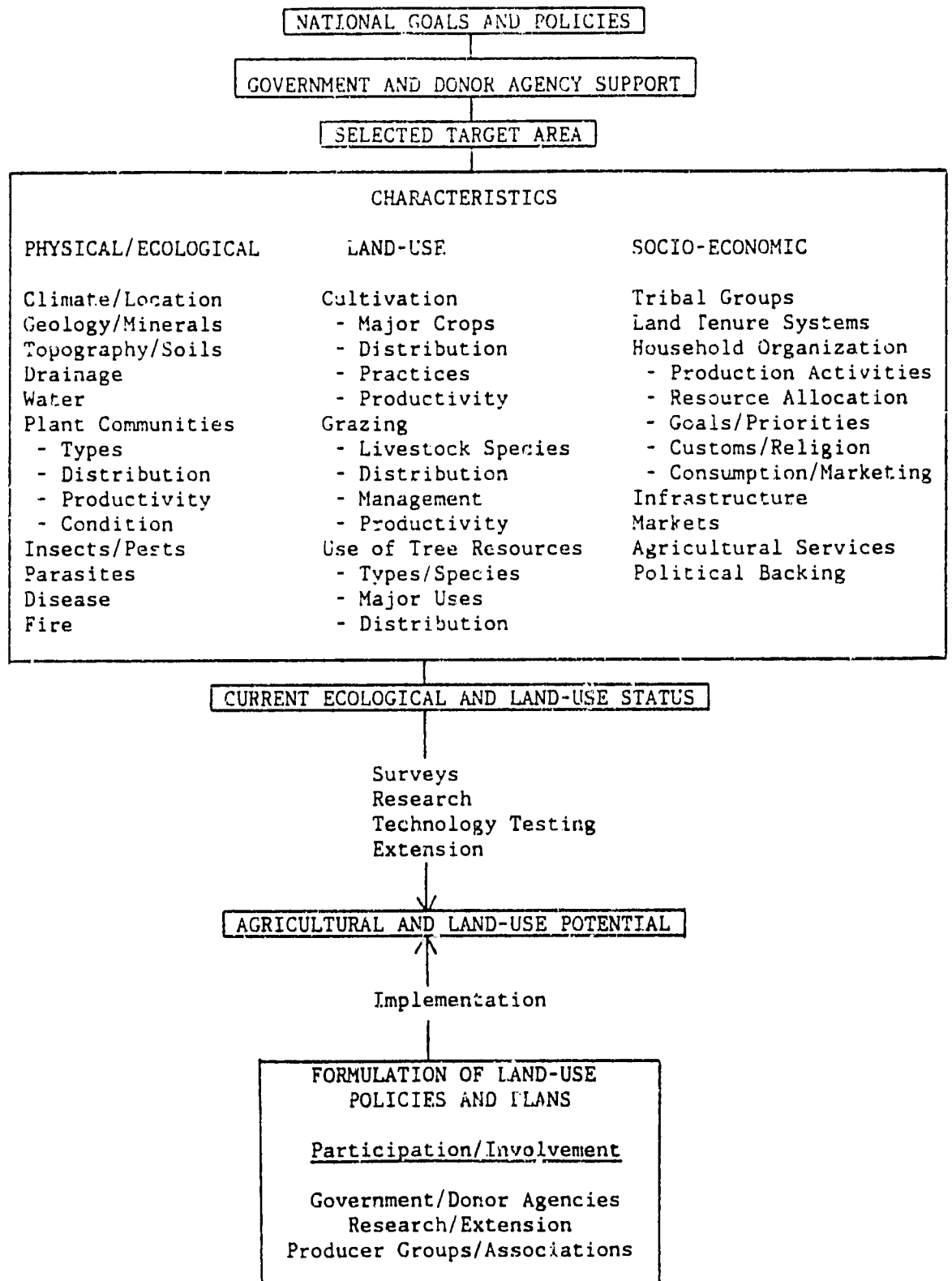
Figure 11 illustrates a simplified model of the physical, ecological, socioeconomic, and political factors associated with developing a comprehensive land-use plan. It is clearly a difficult and complex process, requiring dedicated commitment from all parties concerned for successful implementation. For South Kordofan, this model is applied on a pilot trial basis to areas currently receiving little or no agriculture use due to an absence of dry-season water, and health hazards caused by insect pests, diseases, and mud during the rainy season.

b. Rationale

The region in question is characterized by a mean annual rainfall of 750-850 mm on extensive cracking clay plains south of the Nuba Mountains. Such areas show high agricultural potential and represent a substantial portion of the province. Properly conceived and implemented, a development plan for the region should significantly increase animal and crop productivity, while reducing the scope and intensity of land-use conflicts. The success of the plan could set a precedent from which to model future land-use strategies, not only for other parts of Western Sudan, but for African savanna systems in general.

The proposed trial centers on the strategic development of water with an associated land-use plan to efficiently exploit the productive resources of areas currently unavailable for grazing or cultivation. For an area where no agricultural activities exist, the advantages of pioneering a land-use plan are manifest since there is no necessity for altering or

FIGURE 11: DESIGN CONSIDERATIONS FOR LAND-USE PLANS



manipulating current practices. The plan is designed specifically for, but not limited to, transhumant agro-pastoralists, such as the Baggara, for several reasons:

- ♦ Transhumant groups are the most important livestock producers in Sudan, but their livelihood is threatened by the encroachment of mechanized and traditional cultivation into areas formerly used exclusively for grazing. In this regard, cultivators enjoy the benefits of a rudimentary system of land tenure, although the Government of Sudan holds residual rights to all unsurveyed and unregistered land. This system is primarily usufruct in nature, where rights to cropland can be claimed by individuals, or inherited patrilineally or matrilineally (depending on the tribe in question), as long as the crop-fallow system of cultivation is maintained. For regions with limited resources, use rights can be rented, purchased, borrowed, or obtained as gifts. In areas with plentiful land, usufructory rights can be acquired simply through land clearing. In recent times, cultivation has expanded enormously, frequently in areas ecologically unsuited to cropping. This has been the most significant factor in the deterioration of the northern regions, (i.e., north of 11.45° N. Lat.). In other areas, cultivation is over-exploiting the natural resource base through inappropriate practices, often leading to the abandonment of large tracts of land whose recovery to former conditions could take decades at best.
- ♦ The continuing displacement of transhumant pastoralists is reducing their socio-political stability as well as the productivity of their animals. It is also causing an escalation in land-use conflicts and a disruption in the previous balance between the resource base and its economic utilization. The proposed development provides a potential alternative for transhumants to secure their livelihood and contribute to the long-term productivity of agriculture in the province.
- ♦ The mobile nature of transhumant groups, coupled with their gradual displacement, makes them ideally suited for a transition to a new region with a land-tenure system which provides increased stability and control over their resources. A similar transition by most sedentary groups in South Kordofan is unlikely to be attractive because of their strong socio-cultural ties with specific regions, and a more influential control of land relative to pastoral groups.

c. Design and Organization

The initial stage of the proposed pilot trial should involve:

- ♦ discussions and coordination with the regional and national governments, as represented by the appropriate agencies and departments

- ♦ aerial surveys, complemented by adequate ground truthing, and conducted on a seasonal basis to determine the potential for development in the southern plains by providing information on:
 - (1) current numbers and seasonal distributions of livestock and pastoral settlements in this part of the province;
 - (2) the sources and distribution of surface and ground water;
 - (3) the extent and distribution of major vegetation and soil types;
 - (4) the structure and physiognomy of the vegetation in terms of dominant trees, woody canopy cover, herbaceous cover and height and general phenology, and the relative proportion of perennial and annual grass; and
 - (5) the nature, extent, and distribution of fire and cultivation
- ♦ an interdisciplinary ground team of specialists to select a suitable site for a pilot trial, alone with specific transhumant groups interested in participation
- ♦ an evaluation of natural resources to assess the area's land-use potential in terms of the number of households and livestock which can be supported on a seasonal and year-round basis

Details of these studies are provided in Volume IV of the 84/85 Annual Report. Assuming a positive outcome for undertaking the proposed land-use plan, the site design is then developed, the components of which are outlined below (see Volume IV. for details).

♦ Selection of Participating Groups:

The long-term success of the plan depends on the selection of an appropriate group of participating households. Such a group would, in effect, represent an association of agro-pastoralists who would have specific rights over water and land for grazing and cultivation. The selection process should consider traditional rights, if any, of tribal groups in the region concerned. Access to such areas, and their corresponding pattern of use, should be thus organized in order to establish control over specific territories for common agricultural objectives. The results should lead to reduced land-use conflicts, as well as increased animal and crop productivity over the long term. The ultimate choice for group and household participation should reflect the priorities of grazing rights in the proposed area of the trial.

♦ Water Development:

The location, type, and storage characteristics of the water source developed will largely determine the numbers of households and livestock supported, and are therefore vital to the implementation of the entire plan.

♦ Grazing Management:

One of the most important factors associated with the inefficient utilization of rangelands and the inter-related problems of poor animal nutrition during the dry season, is the absence of a system to control the distribution of animals. An important component of this plan is to introduce a relatively simple system of grazing management to improve the use and availability of forage resources for increasing the productivity of livestock.

♦ Agro-Forestry:

Although the nature of the environment currently limits the use of this region to dry season grazing, the potential for cultivation and forestry is high. In order to realize this potential, the integration of agro-forestry with livestock production is necessary. The plan developed presents one approach to accomplish this, and illustrated its flexibility for accommodating dramatic changes in traditional transhumant systems.

♦ Monitoring and Evaluation:

Monitoring criteria concerning the status and success of the pilot land-use plan are obviously required to determine the potential for large scale application, as well as for making necessary adjustments and improvements. Key elements to examine include:

- (1) the degree to which the proposed plan is followed, both in its entirety and according to its component parts, and whether any observed deviations are detrimental in terms of achieving the specified objectives;
- (2) a socioeconomic evaluation of producer attitudes toward the land-use plan, and of the benefits and costs over a 2-5 year period;
- (3) the adequacy of the water supply and its organization of use;

- (4) the nutritional status and productivity of livestock by species, and the contributing factors involved;
- (5) the composition and productivity of range vegetation in relation to different intensities of grazing;
- (6) the distribution of grazing, and its effect on the seasonal and year-round availability of forage;
- (7) crop productivity and the status of soil phosphorus and nitrogen; and
- (8) the effectiveness of agro-forestry practices in structuring the land-use plan, and in meeting household needs.

d. Conclusions

The high agricultural potential of Western Sudan is unlikely to be realized unless sound land-use policies are formulated with the cooperation of traditional groups for effective implementation. The question of land tenure is vital to the maintenance and improvement of the resource base for the long-term support of crop and livestock production in semi-arid regions. The proposed land-use trial is designed to provide direction in this effort, and will hopefully contribute to the agricultural development of Western Sudan.

LIST OF WSARP PUBLICATIONS

Publication Number	Title	Date
1	Western Sudan Research Project General Outline of Early Planning and Implementation Requirements by J.B. Henson	1979
2	Scope of Work for Initial WSARP Activities	1980
3	Range Management Research in Sudan by D. Dwyer, Consultant (Report on Visit 20/10-10/11, 1979)	1980
4	WSARP First Annual Report (1979-1980)	1980
5	Summary of WSARP Planning Meetings October - November 1980 Including Consultants Reports	1980
6	The Horticultural Resources of the Kordofan Region of Sudan	1982
7	WSARP Second Annual Report	1981
8	Consultants Report on Research Station Development by Mr. D. Meinhart (Report on Visit 24/10-9/11, 1979)	1980
9	Consultant Report on Livestock Production by T. Wilson (Report on Visit 25/3-3/3, 1981)	1981
10	Annual Report on Range Research by W.T. Bunderson	1981
11	WSARP Social Perspectives on Agricultural Research and Development in the Southern Kordofan, Sudan: Systems of Agricultural Production Among the Nuba by Dr. F.P. Araujo	1981
12	Range Research at the Kadugli Station - Review and Recommendations by Dr. D. Dwyer, Consultant (Report on Visit 26/10-16/11, 1981)	1981
13	Work Plan, Volume I, General Research Program Plans	Oct., 1982
14	Work Plan, Volume II, Project History and Functional Structure	Oct., 1982
15	Work Plan, Volume III, Research Plan for the Kadugli and other Stations	Oct., 1982

Publication Number	Title	Date
16	Review of Seed Program in Sudan by J.D. Maguire, Consultant (Report on Visit 8/9 - 7/10, 1982)	Sept.,1982
17	Report of Visit to Sudan to Review Fruit Tree Research Program and Related Factors by Dr. A.H. Krezdorn, Consultant (Report on Visit 30/3-20/4, 1981)	May,1983
18	Work Plan, Volume IV, Initial Research Proposals, Kadugli Research Station	Aug.,1983
19	Fourth Annual Report	Aug.,1983
20	Summary of the Main Points-WSARP/ARC Regional Planning Workshops. Held in El Obeid, Kordofan and El Fasher, Darfur, April 9-13, 1983 (J.J. Riley Editor)	Aug.,1983
21	Report of Visit to Sudan to Review the Organization and Development of Research Support for the WSARP Experiment Stations - Consultant Report by E.W. Nunn	Feb., 1984
22	Research Program for the Kordofan Region (1984-85)	May,1984
23	Application of Farming Systems Research and Development to an Extensive Sedentary Livestock Production System in Southern Kordofan (Cook, Bunderson, Fadlalla, and Henson)	Nov.,1983
24	Kadugli Agronomy Research Report 1983 (Gingrich, Kenani, El Seid, Bunderson)	Apr.,1984
25	Social Science Report 2/82 to 3/83 (Teitelbaum)	Aug.,1984
26	Gum Arabic as an Evaporation Retardant and Its Effect on Sorghum Seedling Growth and Establishment in Goz Sands (Arya)	Apr.,1984
27	Development of the Horticultural Potential of Kordofan Region of Sudan (Obeidalla and Riley)	Sept,1984
28	Adoption of a New Technology and Problems Encountered in a Nuba Village (Patrick)	Sept,1984

Publication Number	Title	Date
29	Range/Livestock Research Activities 1982-83 (Cook, Bunderson, Fadlalla)	Aug.,1984
30	The Sedentary Production Systems in the Nuba Mountain Area (Sabah and Patrick)	Oct.,1984
31	Consulting Report: Range/Livestock Research Review and Recommendations by Dr. D. Dwyer (Report on Visit 18/8-5/9, 1984)	Oct.,1984
32	Farming Systems Research: Its Strengths and Weaknesses and the Need to Link Farm Research to Macro-Economic Circumstances (Winch)	Dec.,1984
33	Fifth Annual Report	Feb.,1985
34	Hybrid Sorghum Production in the Sudan (McDonald)	Jan.,1985
35	Soil and Water Management and Conservation Program, North Kordofan (Arya)	Feb.,1985
36	Research Program for the Kordofan Region: 1985-1986	May, 1985
37	Increasing Crop Productivity of Western Sudan - Results of Selected Agronomic Trials	June,1985
38	Recommended Water Conservation/Utilization Interventions and Research Directions in Kordofan Region of Western Sudan	July 1985
39	WSARP Sixth Annual Report	Oct.,1985
40	Soil and Water Management/Conservation Research in the Kordofan Region of Sudan: Report on Research Activities and Results for the 1984-85 Season	In Press
41	WSARP Research Program Results 1984/1985- Volume 1 - Summary of Kadugli Sedentary and Transhumant Production Systems Research Program Results	Oct.,1985